Comparison of Ecological Landscapes

This chapter provides a basic ecological background of the natural resources in the state and summarizes the socioeconomic characteristics across Wisconsin. The chapter compares the physical, ecological, and socioeconomic characteristics among the ecological landscapes of Wisconsin. It points out the physical, biological, and historical differences among ecological landscapes that result in somewhat different ecological management opportunities within each landscape. (Ecological management opportunities by ecological landscape can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management.") This same information is useful for considering the differing socioeconomic characteristics found across the state.

Physical Characteristics

Physical characteristics directly affect the biotic parts of ecosystems. Physical and biotic features interact with each other to create the overall ecology of an area. Climate, bedrock, landforms, soils, and hydrology are among the major determinants of which plants and animals are found in any given area. It is important to understand the physical characteristics of an ecological landscape to fully understand its ecology. This section describes and compares the physical features among and within ecological landscapes.

Size

Within each of the 16 ecological landscapes in Wisconsin there are similar ecological characteristics and management opportunities; see the "Ecological Landscapes of Wisconsin" map in Appendix H, "Statewide Maps," in Part 3 of this handbook ("Supporting Materials"). Ecological landscapes range in size from 431,842 acres in the Northwest Lowlands to 6,170,674 acres in the Western Coulees and Ridges. Ecological landscapes range from 1.2% to 17.2% of the total area of the state (Table 3.1). The two largest ecological landscapes, the North Central Forest and the Western Coulees and Ridges, are each over 6 million acres (17% and 17.2%, respectively, of the area of the state). Nine ecological landscapes are from 1 to 5 million acres (3.5%–13.8% of the area of the state) in size, and five ecological landscapes are less than 1 million acres (1.2%–2.8% of the area of the state). When comparing the physical, biological, and socioeconomic characteristics among ecological landscapes, it is important to remember that they vary greatly in size.

Climate

Climate is an important determinant of the ecology in an area, especially at large scales (e.g., at regional or continental scales, although local effects, such as those occurring along and near the Great Lakes shores, can be highly significant). Climate in Wisconsin, from a statewide perspective, is primarily affected by latitude, distance from oceans, prevailing wind patterns, and topographic features (Martin 1965). Wisconsin is at a latitude that receives sufficient heat from the sun to give it a temperate climate. It is far enough south that it escapes the polar extremes of the arctic. Wisconsin is approximately 900–1,000 miles from both the Atlantic Ocean and the Gulf of Mexico. This results in a continental climate with four distinct seasons. The waters of Lakes Superior and Michigan moderate air temperatures in their vicinity (cooling when it's warm; warming when it's cold), making the range of extreme temperature less than in some other midwestern states such as Minnesota (Lake Superior borders northeastern Minnesota but is "downwind") and North Dakota. Wisconsin lies in a belt of prevailing westerly winds, resulting in a succession of cyclonic storms, determined by areas of high and low barometric pressure (Martin 1965). The climate in Wisconsin is considered humid, often receiving moist air from the Gulf of Mexico. The topography in Wisconsin influences the climate, especially at local scales. Ranges of hills often receive more precipitation, and temperatures may be cooler. However, topography in Wisconsin is not pronounced enough to affect regional climate.

Within Wisconsin there are two major climatic zones, one in southern and one in northern Wisconsin. The area between these two climatic zones is called the Tension Zone (Figure 3.1), which bisects the state in a southeast-northwest direction (Curtis and McIntosh 1951, Curtis 1959). Curtis and McIntosh (1951) and Curtis (1959) defined the Tension Zone by the overlap of vegetation from two different floristic provinces (the prairie-forest and northern hardwoods provinces), and this floristic transition correlates very well with climatic conditions. The Tension Zone also roughly corresponds to the 43°F mean annual soil temperature delineation of frigid soils to the north and mesic soils to the south (J. Bockheim, University of Wisconsin-Madison, personal communication).

The ecological landscapes south of the Tension Zone in Wisconsin generally tend to have longer growing seasons, warmer summers, warmer winters, and more precipitation than the ecological landscapes north of the Tension Zone. Flora and fauna differ in northern and southern Wisconsin but often intermix within the Tension Zone, creating unusual and sometimes highly diverse plant and animal assemblages. Although geology, landforms, and soils play important roles, land uses are different north and south of the Tension Zone. Agriculture is much more common south of the Tension Zone, and forests and forestry-related activities are much more common to the north.

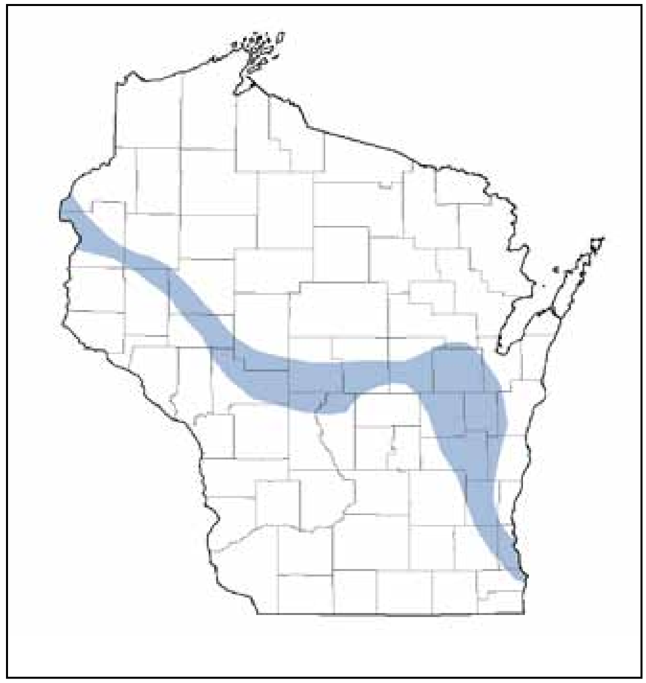


Figure 3.1. *Estimated location of the Tension Zone, adapted from Curtis (1959).*

Lakes Michigan and Superior have important effects on the climate within Wisconsin. Ecological landscapes adjacent to the Great Lakes generally tend to have warmer winters, cooler summers, and higher precipitation, especially snow. This results in longer growing seasons and different land uses along and near the Great Lakes. For example, apple and cherry orchards occur on the Door Peninsula along Lake Michigan, and apples and other fruits are grown on the Bayfield Peninsula near Lake Superior. Also notable is the Lake Superior snowbelt, where areas south and east of Lake Superior receive significantly more snowfall than areas inland. Warm moist air is blown off the lake in winter over the cooler, higher land, resulting in more snowfall.

Topography can affect the local climate in Wisconsin. Cold air can settle into low lying areas during summer, resulting in colder nights and frosts during the growing season. An example is the Central Sand Plains Ecological

Table 3.1. *Size and percent of the state for each ecological landscape (based on Wisconsin DNR GIS data).*

Ecological landscape	Abbreviations used in tables and figures	Area (acres)	Area (sq. mi.)	Percent area of state
Northwest Lowlands	NWL	431,842	675	1.2%
Southern Lake Michigan Coastal	SLMC	539,830	843	1.5%
Western Prairie	WP	697,633	1,090	1.9%
Superior Coastal Plain	SCP	905,929	1,416	2.5%
Northeast Sands	NES	987,176	1,542	2.8%
Southwest Savanna	SWS	1,248,126	1,950	3.5%
Northwest Sands	NWS	1,251,723	1,956	3.5%
Northern Lake Michigan Coastal	NLMC	1,282,877	2,004	3.6%
Northern Highland	NH	1,331,970	2,081	3.7%
Central Sand Hills	CSH	1,388,705	2,170	3.8%
Central Lake Michigan Coastal	CLMC	1,755,089	2,742	4.9%
Central Sand Plains	CSP	2,188,861	3,420	6.1%
Forest Transition	FT	4,658,498	7,279	13.0%
Southeast Glacial Plains	SEGP	4,943,731	7,725	13.8%
North Central Forest	NCF	6,107,516	9,543	17.0%
Western Coulees and Ridges	WCR	6,170,674	9,642	17.2%
State total		**35,890,180**	**56,078**	**100.0%**

Landscape, where frost can occur in any month of the year. At even smaller scales, cold air can settle into low lying areas and create "frost pockets" that may limit tree growth. Locally high elevations can result in increased precipitation; for example, the Penokee Range (in Iron and Ashland counties) rises steeply from the shores of Lake Superior, forcing moist air moving off the lake to ascend and cool, resulting in a large amount of winter snowfall. These local climates partially determine which plants and animals can survive and whether agriculture can be viable.

Because of the climate, three major vegetation types meet in Wisconsin: the boreal forest from the north, the deciduous forest from the east, and the prairies from the west. The occurrence of major vegetation types is largely a function of temperature and mean annual precipitation, although other factors such as fire frequency, soil type, and snow can be important. Climate, along with bedrock, landforms, and soils, can determine what plants will occur in different parts of a continent, region, or state. Many species reach their range limits in Wisconsin due to climate. For example, trees such as American beech (*Fagus grandifolia*) and eastern hemlock (*Tsuga canadensis*) reach their western range limits here. Prairie species with ranges centered in the Great Plains such as dotted blazing star (*Liatris punctata*) reach their eastern range limits in Wisconsin. Many ***boreal species***, such as the carnivorous common butterwort (*Pinguicula vulgaris*), reach their southern range limits in Wisconsin, and many southern species reach their northern range limits here (e.g., American sycamore [*Platanus occidentalis*]).

Below is a comparison of how climate differs and affects the ecology of the ecological landscapes in the state. Table 3.2 provides a summary of climatic differences among ecological landscapes in Wisconsin.

*Dotted blazing star (*Liatris punctata *var.* nebraskana*) has been found along the northwestern edge of the state at its easternmost range limit. Photo by Robert H. Read.*

Table 3.2. *Climate comparisons among ecological landscapes in Wisconsin.*

Ecological landscape	Mean temperatures (°F)	Mean August highs (°F)	Mean January lows (°F)	Annual precipitation (inches)	Annual snowfall (inches)	Growing season (days)
Central Lake Michigan Coastal	45.1	80.3	0	31.1	43.4	160
Central Sand Hills	45.5	81.2	4.1	32.8	38.7	148
Central Sand Plains	43.8	80.7	2.5	32.8	45.0	135
Forest Transition	41.9	80.4	-1.0	32.6	50.2	133
North Central Forest	40.3	79.3	-2.0	32.3	63.0	115
Northeast Sands	41.6	78.8	1.5	31.8	57.5	122
Northern Highland	39.5	77.5	-1.8	31.6	68.1	122
Northern Lake Michigan Coastal	42.8	79.0	0	31.2	46.1	140
Northwest Lowlands	41.8	80.4	-2.0	30.6	49.3	122
Northwest Sands	41.3	80.4	-2.0	31.4	61.0	121
Southeast Glacial Plains	45.9	81.2	5.7	33.6	39.4	155
Southern Lake Michigan Coastal	47.2	80.9	8.7	34.0	41.9	169
Southwest Savanna	45.6	81.2	6.5	35.2	39.9	153
Superior Coastal Plain	40.2	78.5	-2.0	32.0	87.4	122
Western Coulees and Ridges	43.7	81.2	0.4	32.6	43.0	145
Western Prairie	43.7	80.7	0.4	32.2	45.4	145

Source: Wisconsin State Climatology Office (2011).

Two species that are present in Wisconsin year-round, Northern Saw-whet Owl (Aegolius acadicus) *and Ermine* (Mustela erminea). *Ermines are adapted to change color from dark brown to almost completely white in the winter. Photos by Herbert Lange.*

Temperatures

Wisconsin has a continental climate, with cold winters and warm summers. During more than one-half of the winters, temperatures fall to -40°F or lower at one or more weather stations in northern Wisconsin (UWEX 2010). Winter temperatures fall to -30°F at some northern weather stations almost every year. Summer temperatures are above 90°F for an average of three days annually in northern Wisconsin and 14 days in southern Wisconsin (UWEX 2010). Occasionally, freezing temperatures are reported during the summer months in the Central Sand Plains Ecological Landscape.

Mean Annual Temperature

Mean annual temperature is based on daily temperatures recorded near the land surface. It is the average of monthly mean temperatures, which are the average of the midpoint of daily maximum and minimum temperatures. Mean annual temperature is useful at larger scales to determine general temperature conditions and trends for regions of the state and sometimes among ecological landscapes. However, it is not always associated with local ecological differences within or among ecological landscapes.

Mean annual temperatures generally decrease with higher latitude in Wisconsin (Figure 3.2). The Northern Highland Ecological Landscape has the lowest mean annual temperature (39.5°F), and the Southern Lake Michigan Coastal has the highest (47.2°F). There is a difference of almost four degrees in mean annual temperature of northern ecological landscapes (41.2°F) compared to southern ecological landscapes (45.1°F), which affects the ecology and prevalent land uses in those regions of the state. Generally, the mean annual temperature in ecological landscapes in the eastern part of southern Wisconsin (Southeast Glacial Plains, Southern Lake Michigan Coastal, Central Lake Michigan Coastal, and Central Sand Hills) was more than one degree warmer than those in the west (Southwest Savanna, Western Coulees and Ridges, Central Sand Plains, and Western Prairie). There was little difference in the mean annual temperature between the ecological landscapes in the eastern and western parts of northern Wisconsin, with the exception that the Northern Lake Michigan Coastal Ecological Landscape was almost one degree warmer

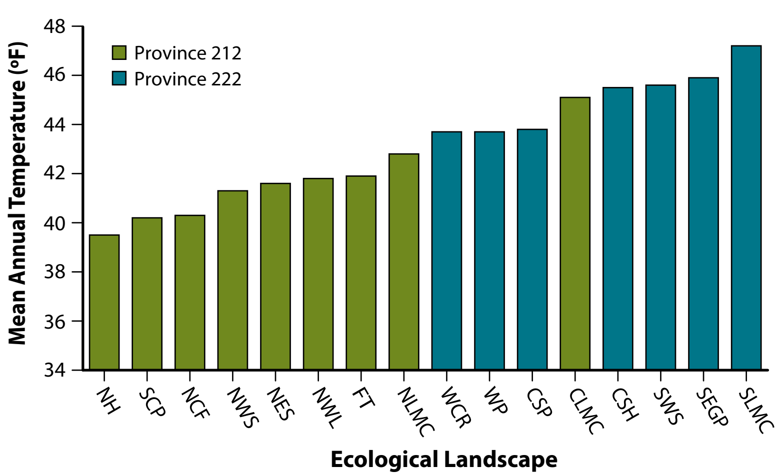


Figure 3.2. *Mean annual temperatures among ecological landscapes, 1971–2000. Data from Wisconsin State Climatology Office (2011). (See Table 3.1 for key to abbreviations.)*

than the rest of the northern ecological landscapes. The North Central Forest and Forest Transition ecological landscapes were not included in this east-west analysis because they span both eastern and western Wisconsin, and the Northern Highland was not included because it is in the center of northern Wisconsin.

Temperatures are moderated locally in ecological landscapes bordered by Lake Michigan and Lake Superior (Southern Lake Michigan Coastal, Central Lake Michigan Coastal, Northern Lake Michigan Coastal, and Superior Coastal Plain). Winters are generally warmer and summers cooler near the Great Lakes than farther inland.

Winter Temperatures

The mean January low temperature is the lowest temperature recorded for the month, averaged over 1971–2000. Mean January low temperatures and mean January temperatures are useful to compare winter temperatures among ecological landscapes. Colder winters partially determine which plant and animal species can survive.

Mean January low temperatures as well as mean January average temperatures generally decrease with higher latitude in Wisconsin (Figure 3.3). The North Central Forest, Superior Coastal Plain, Northwest Lowlands, and Northwest Sands have the lowest mean January low temperature (-2°F), and the Southern Lake Michigan Coastal has the highest (8.7°F). Ecological landscapes north of the Tension Zone generally have lower mean January low temperatures (-1.2°F) than ecological landscapes south of it (3.5°F). Generally, ecological landscapes in the eastern part of southern Wisconsin (Southeast Glacial Plains, Southern Lake Michigan Coastal, Central Lake Michigan Coastal, and Central Sand Hills) were two degrees warmer than those in the west (Southwest Savanna, Western Coulees and Ridges, Central Sand Plains, Western Prairie). January mean low temperatures in northwestern ecological landscapes were more than one degree colder than northeastern ecological landscapes. The North Central Forest and Forest Transition ecological landscapes were not included in this analysis because they span both eastern and western Wisconsin, and the Northern Highland was not included because it is in the center of northern Wisconsin.

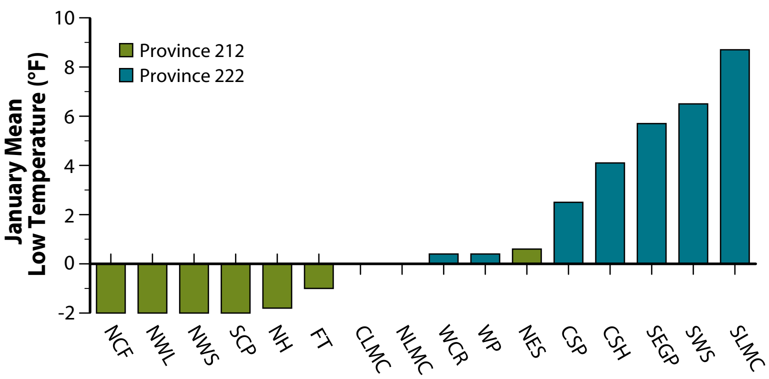


Figure 3.3. *Mean January low temperatures among ecological landscapes, 1971–2000. Data from Wisconsin State Climatology Office (2011). (See Table 3.1 for key to abbreviations.)*

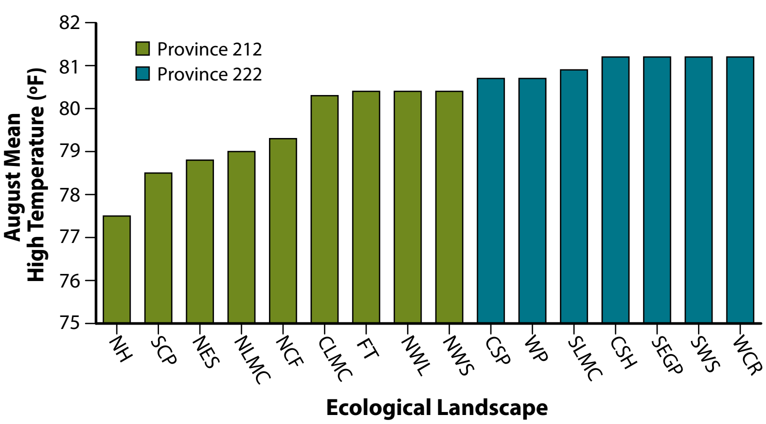


Figure 3.4. *Mean August high temperatures among ecological landscapes, 1971–2000. Data from Wisconsin State Climatology Office (2011). (See Table 3.1 for key to abbreviations.)*

Summer Temperatures

The mean August high temperature is the highest temperature recorded for that month, averaged over 1971–2000. This measurement and the mean August monthly temperature are useful to compare how hot summers are among ecological landscapes. Hotter summers influence survival of plant and animal species.

Mean August high temperatures as well as mean August temperatures generally decrease with higher latitude in Wisconsin (Figure 3.4). The Northern Highland Ecological Landscape has the lowest mean August high temperature (77.5°F), and the Western Coulees and Ridges, Southwest Savanna, Central Sand Hills, and Southeast Glacial Plains ecological landscapes were the highest (81.2°F). Ecological landscapes south of the Tension Zone generally have higher mean August high temperatures (80.9°F) than ecological landscapes north of the Tension Zone (79.3°F). However, mean August high temperatures in northwestern ecological landscapes were almost one degree hotter than northeastern ecological landscapes, while southeastern ecological landscapes were almost the same as those in the western part of the state. The North Central Forest and Forest Transition ecological landscapes were not included in this analysis because they span both eastern and western Wisconsin, and the Northern Highland was not included because it is in the center of northern Wisconsin.

Growing Season

The average date of the last spring freeze ranges from early May along the Lake Michigan coastal area and southern counties to early June in the northernmost counties. The first autumn freezes occur in late August and early September in northern Wisconsin and the central lowlands and in mid-October along the Lake Michigan coastline. However, a July freeze is not unusual in northern Wisconsin and the central Wisconsin lowlands.

Growing degree days are a measure of accumulated heat over the growing season, which affects plant growth, emergence of insects, and other ecological processes. Growing degree days are calculated as the mean temperature minus the base temperature for each day. Thirty-two degrees is used as the base temperature in this handbook since that is when frost usually occurs. Growing degree days are accumulated by adding each day's contribution as the season progresses. This yields a measure of the estimated growing season.

The growing season varies from a minimum of 115 days in the North Central Forest Ecological Landscape to a maximum of 169 days in the Southern Lake Michigan Coastal Ecological Landscape (Figure 3.5). The growing season is an average of 13 days longer in the eastern part of southern Wisconsin compared to the western part. Northeastern ecological landscapes have growing seasons that are nine days longer, on average, than northwestern ecological landscapes. The North Central Forest and Forest Transition ecological landscapes were not included in this analysis because they span both eastern and western Wisconsin, and the Northern Highland was not included because it is in the center of northern Wisconsin. Generally, ecological landscapes in the northern part of the state (Province 212) have fewer growing degree days (125 days) on average than ecological landscapes in the south (Province 222) (151 days) (Figure 3.6).

The growing season is affected by the Great Lakes and by local topography. It is moderated locally in ecological landscapes adjacent to Lake Michigan and Lake Superior. Interestingly, the growing season is longer along the Mississippi River Valley than in other parts

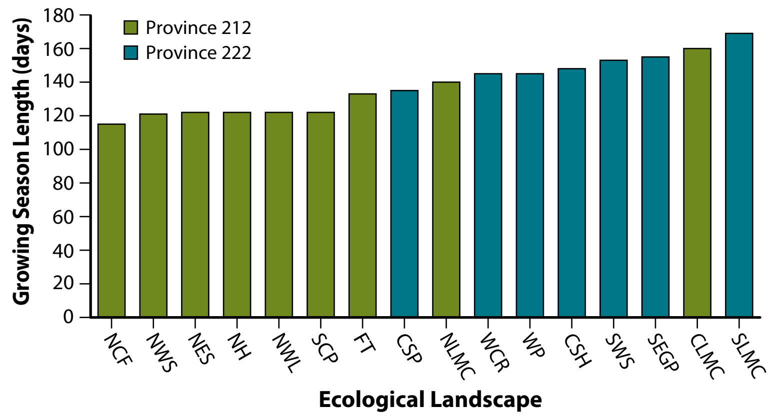


Figure 3.5. *Growing season length in days among ecological landscapes, 1971–2000. Growing season length based on 32°F. Data from Wisconsin State Climatology Office (2011). (See Table 3.1 for key to abbreviations.)*

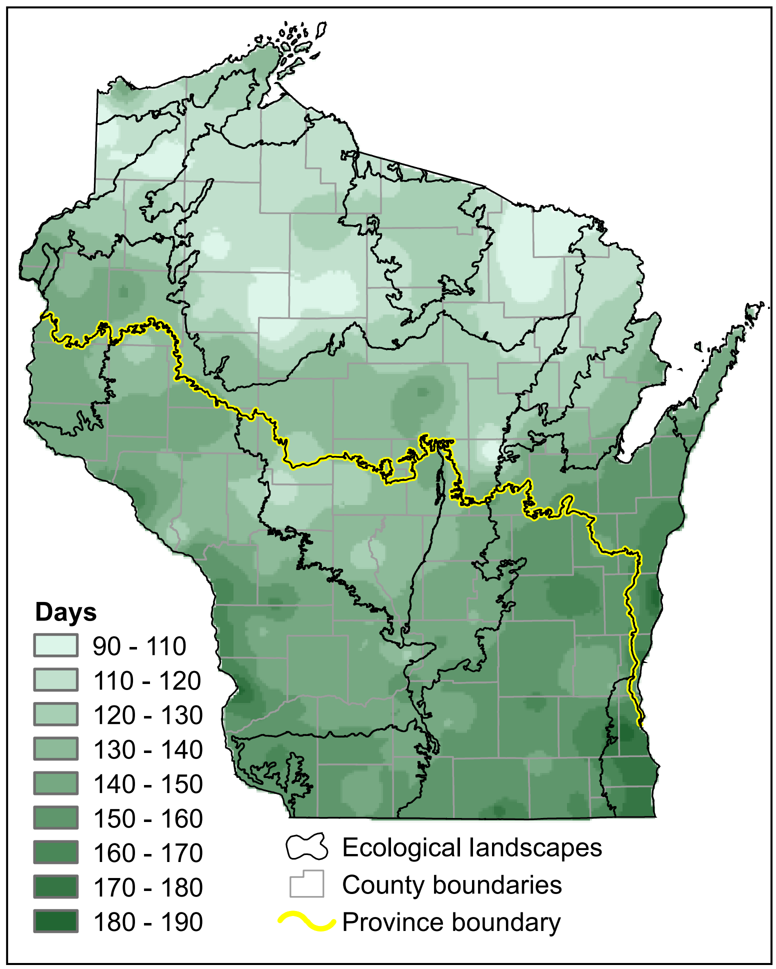


Figure 3.6. *Growing season length in Wisconsin, 1971–2000. Growing season length based on 32°F, using median data for 142 weather stations in Wisconsin. Data from Wisconsin State Climatology Office (2011).*

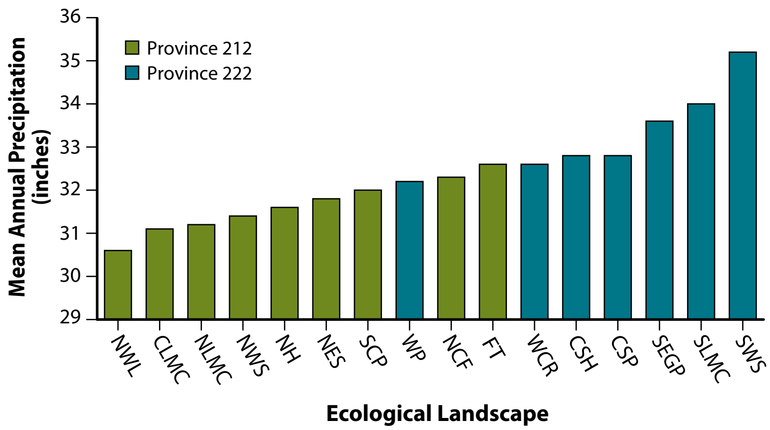


Figure 3.7. *Mean annual precipitation among ecological landscapes, 1971–2000. Data from Wisconsin State Climatology Office (2011). (See Table 3.1 for key to abbreviations.)*

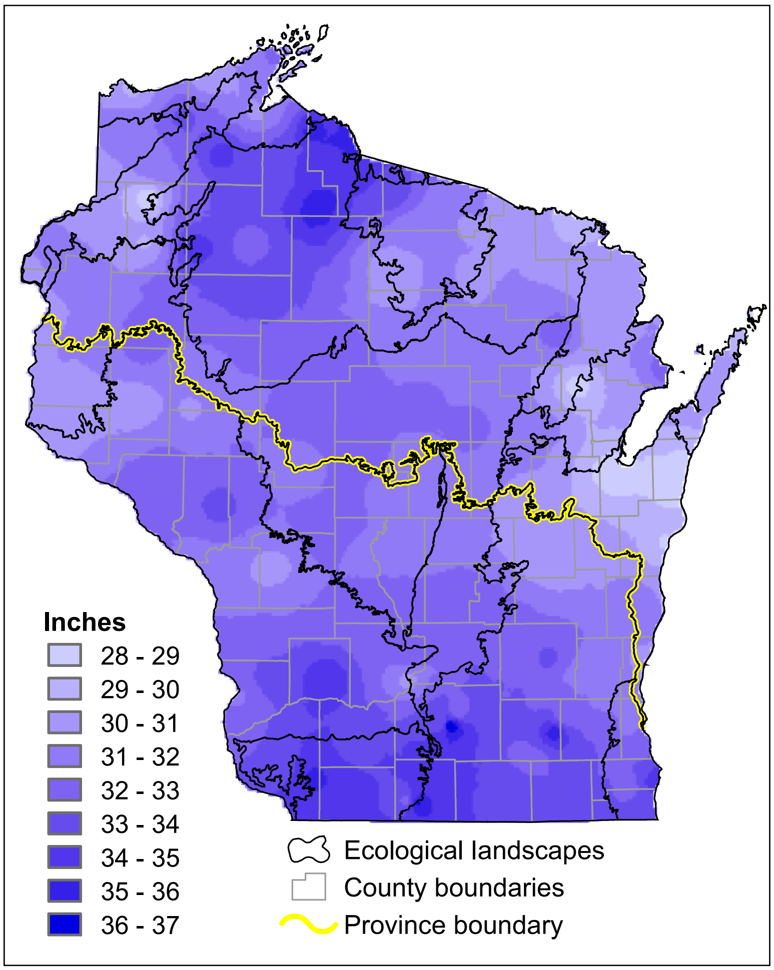


Figure 3.8. *Mean annual precipitation in Wisconsin, 1971–2000, using median data from 142 weather stations. Data from Wisconsin State Climatology Office (2011).*

of the state (Figure 3.6), likely due to warmer winds off the western plains. Some speculate that it is due to the heating of the bedrock bluffs. Also noteworthy is the low number of growing degree days in the Central Sand Plains (135 days), attributed to cold air drainage in its lower elevations.

The length of the growing season has profound effects on the types of plants that can grow in certain parts of the state and where certain agricultural crops can be best grown. It is one of the primary factors used to explain why agriculture is common in southern Wisconsin and in the Forest Transition Ecological Landscape but not in ecological landscapes farther to the north and in the western part of the Central Sand Plains Ecological Landscape.

Precipitation

The mean annual precipitation in Wisconsin is 32 inches, ranging from 28 to 34 inches. About two-thirds of the annual precipitation falls during the growing season (UWEX 2010). Thunderstorms average about 30 per year in northern Wisconsin to about 40 per year in southern Wisconsin and occur mostly in the summer. Occasional hail, wind, and lightning damage are reported with those storms.

Mean annual precipitation varies from 30.6 inches in the Northwest Lowlands Ecological Landscape to 35.2 inches in the Southwest Savanna Ecological Landscape (Figures 3.7 and 3.8). Ecological landscapes in the northern part of the state (Province 212) have less mean annual precipitation (31.7 inches) than ecological landscapes in the south (Province 222) (33 inches). On average, there is little difference in precipitation between the eastern and western parts of the state. However, precipitation is generally lower in the southeastern part of the state and higher in the southwest, although there is considerable local variation. The Southwest Savanna Ecological Landscape and far southern Wisconsin receive the most precipitation (north central Wisconsin also receives a large amount of precipitation; Figure 3.8), which is critical for their native plants and agricultural crops. Although there is variation in the amount of precipitation that occurs among ecological landscapes (almost 5 inches), it is not the sole driving factor in the distribution of natural community types. Soils, landforms, disturbance, temperatures, ***evapotranspiration***, and growing degree days are also important. However, these factors combined with precipitation affect where natural communities occur and where agricultural crops can be grown.

Snowfall

The average seasonal snowfall varies from about 30 inches at Beloit to well over 100 inches in northern Iron County along the steep northern slope of the Penokee Range. The heavy snowfall along the Penokee Range is a result of warm moist air blown off Lake Superior in winter over the cooler, higher land, resulting in more snowfall. The mean dates of first snowfall of consequence (one inch or more) vary from early November in northern localities to early December in southern Wisconsin counties. Average annual duration of snow cover ranges from 85 days in southernmost Wisconsin to more than 140 days along Lake Superior. The snow cover acts as protective insulation for grasses, autumn seeded grains, alfalfa, and other vegetation. Where snow is deep, it protects vegetation from deer browsing.

Mean annual snowfall varies from 38.7 inches in the Central Sand Hills Ecological Landscape to 87.4 inches in the Superior Coastal Plain Ecological Landscape (Figure 3.9). It exhibits an opposite pattern from rainfall, with more snowfall in northern Wisconsin and less in the south (Figure 3.10). There is a pronounced "lake effect snowfall" in the eastern part of the Superior Coastal Plain Ecological Landscape and a small northern part of the North Central Forest Ecological Landscape where prevailing northwesterly winds in winter bring moisture off Lake Superior and drop it as snow when it reaches the higher elevation of the Penokee Range. Lake effect snowfall also occurs along Lake Michigan, but the prevailing winds generally move winter weather systems to the east. So these areas get large amounts of snowfall on the back sides of low pressure systems, when the winds are from the east, off Lake Michigan.

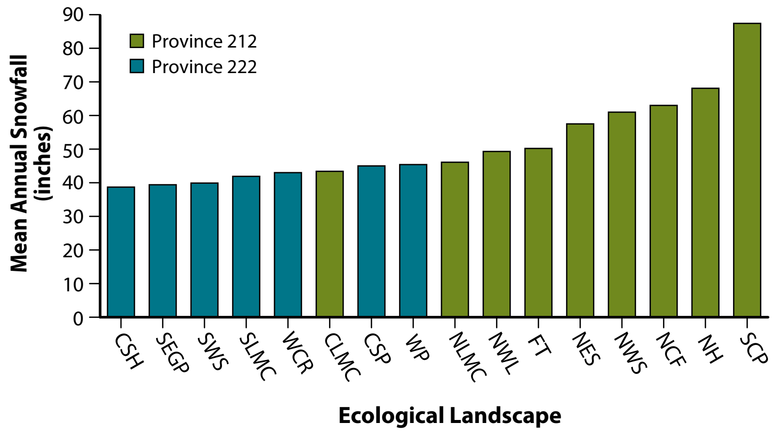


Figure 3.9. *Mean annual snowfall among ecological landscapes, 1971–2000. Data from Wisconsin State Climatology Office (2011). (See Table 3.1 for key to abbreviations.)*

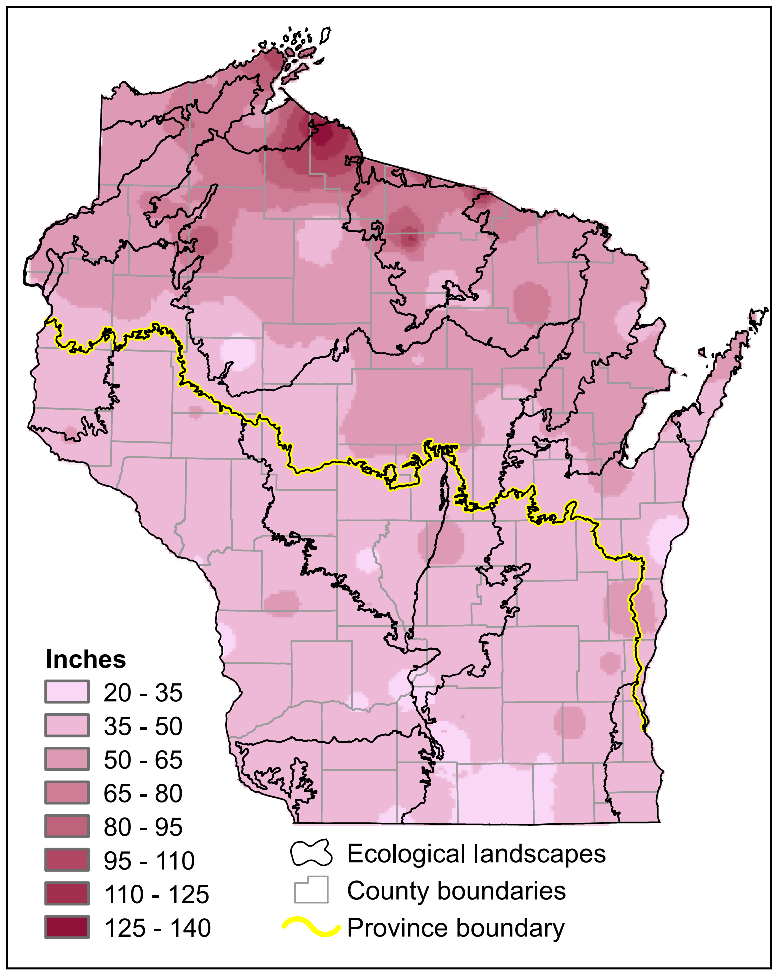


Figure 3.10. *Mean annual snowfall in Wisconsin, using median data from 142 weather stations in Wisconsin, 1971–2000. Data from Wisconsin State Climatology Office (2011).*

Bedrock Geology

Underlying bedrock is important to the ecology and economy of the state. Underlying bedrock affects the landforms, water chemistry, soil composition, and minerals available for vegetation growth. The resulting ecology from underlying bedrock affects the economy by influencing agricultural and forestry opportunities and the water, minerals, and other natural resources that are available for human use. Wisconsin is underlain by igneous, metamorphic, and sedimentary (carboniferous, shale, and sandstone) rocks. For a discussion of the origin and age of these rocks, see Dott and Attig (2004) and Martin (1965).

Igneous and Metamorphic Rock

Generally, older igneous and metamorphic rocks are found in the north central and northwest part of the state (see the "Bedrock Geology" map in Appendix H, "Statewide Maps," in Part 3 of the handbook, "Supporting Materials"). The "Wisconsin dome" is an almost continuous dome of igneous rock underlying the Northern Highland, North Central Forest, and Northeast Sands ecological landscapes and the eastern part of the Forest Transition Ecological Landscape. There is also igneous rock under the Northwest Lowlands, the southern part of the Northwest Sands, and extreme western part of the Forest Transition ecological landscapes (Figure 3.11). Intrusions of quartzite occur as prominent outcrops in the Baraboo Hills in the Western Coulees and Ridges, in the Blue Hills and the southeastern corner of the North Central Forest Ecological Landscape at McCaslin Mountain. Here the resistant bedrock remains at higher elevations and as rugged hills compared to the surrounding areas.

Igneous bedrock affects the ecology of an area in a number of different ways. Although most of the igneous bedrock is overlain with glacial materials, it controls the surface features in some areas. For example, the Penokee Range is overlain by glacial material, but the bedrock beneath it has caused the dominant landform to be a series of high ridges roughly parallel to the southern Lake Superior shoreline.

Bedrock can affect water chemistry of lakes and the morphology of streams. Since igneous rock is resistant to weathering and erosion, streams do not easily cut through igneous bedrock to form deep valleys. Lakes underlain with igneous or metamorphic rock can be less fertile and more acidic than lakes underlain by carbonate rock. This can lead to less buffering capacity of the water if acid deposition is occurring. Bedrock, by its impacts on water chemistry (e.g., pH and alkalinity) and substrate material availability, can directly or indirectly affect which aquatic plants, animals, and wetlands will occur there.

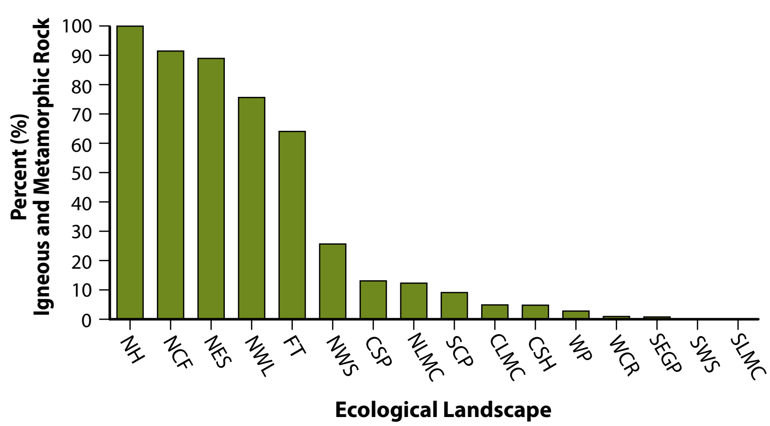


Figure 3.11. *Percentage of igneous and metamorphic rock in the ecological landscapes of Wisconsin. Data from Wisconsin Geological and Natural History Survey. (See Table 3.1 for key to abbreviations.)*

Sandstone

Sandstone is a sedimentary rock that underlies large portions of northwestern, western, central, and a small band of northeastern Wisconsin. The location of sandstone in the state appears as a large U-shaped area surrounding the dome of igneous rock in north central Wisconsin (see the "Bedrock Geology" map in Appendix H, "Statewide Maps"). Sandstone underlies the Superior Coastal Plain; most of the Northwest Sands; the western portion of the Forest Transition, Central Sand Plains, and Central Sand Hills; the northwestern part of the Southeast Glacial Plains; a narrow band running northeast-southwest through the western part of the Central Lake Michigan Coastal; the eastern part of Northeast Sands; and the western part of the Northern Lake Michigan Coastal ecological landscapes (Figure 3.12). Sandstone is interlayered with carbonate rock in the Western Prairie, Western Coulees and Ridges, Southwest Savanna, and southwestern part of Southeast Glacial Plains ecological landscapes.

Sandstone bedrock affects the ecology of an area in a number of ways. Erosion of sandstone bedrock can control surface features, especially in the mostly unglaciated Southwest Savanna and Western Coulees and Ridges ecological landscapes where sandstone bedrock is exposed as cliffs and ***talus slopes***. Sandstone also occurs as ***buttes*** and ***pillars***, mostly in the Central Sand Plains where some of these features were islands or "stacks" in former Glacial Lake Wisconsin (see map of former Glacial Lake Wisconsin in Appendix H, "Statewide Maps," in Part 3 of the handbook. In addition, the relatively soft nature of sandstone allows it to weather and erode fairly easily compared to igneous and metamorphic rocks. This has produced steep-sided ridges and deep valleys in parts of southwestern Wisconsin. Bedrock can affect water chemistry of lakes and morphology of streams. Streams can cut through sandstone more easily than many other rock types, which can create ***entrenched meanders***, long series of cliffs, and ***high-gradient streams***. Lakes underlain by sandstone or sandy glacial deposits can be less fertile and sometimes more acidic than lakes underlain by carbonate rock, affecting the aquatic life that occurs there.

Carbonate Rock

Carbonate rock (dolomite and limestone) is a sedimentary rock that underlies much of eastern, southern, and western Wisconsin. The location of carbonate bedrock in the state appears as a large, U-shaped area bordering the sandstone belt that surrounds the dome of igneous rock in north central Wisconsin (see the "Bedrock Geology" map in Appendix H, "Statewide Maps"). Carbonate rock underlies the Southern Lake Michigan Coastal, the eastern two-thirds of the Southeast Glacial Plains, the eastern three-quarters of the Central Lake Michigan Coastal, and eastern part of the Northern Lake Michigan Coastal ecological landscapes. Carbonate rock is intermixed with sandstone in the southwestern part of the Southeast Glacial Plains and in the Southwest Savanna, Western Coulees and Ridges, and Western Prairie ecological landscapes (Figure 3.13). Although not always carbonate, a small amount of shale is found near Lake Michigan and in southwestern Wisconsin.

Carbonate bedrock affects the ecology of an area in a number of ways. In some areas, it controls surface features. This is especially true in the mostly unglaciated Southwest Savanna and Western Coulees and Ridges, where carbonate bedrock (mostly dolomite) outcrops as cliffs and talus slopes. The more resistant dolomite (and some sandstone) formations result in ridges, while the softer rocks erode more easily and become valleys. The Niagara Escarpment is a prominent ridge of resistant Silurian dolomite that runs from southeastern Wisconsin north and east through the Door Peninsula and Grand Traverse Islands in Lake Michigan (from there it continues eastward across Upper Michigan, southern Ontario, and parts of New York State, forming Niagara Falls, among other well-known features). The gently sloping eastern side of this same ridge is exposed in many places along the Lake Michigan shore of the northern Door Peninsula and also forms the base of the Grand Traverse Islands.

Fractures in carbonate bedrock channel water; this not only affects local hydrology but also creates subterranean habitats as the fractures are enlarged over time via the action of moving water, ice, and solution, providing breeding, roosting, and hibernating areas for bats and other organisms.

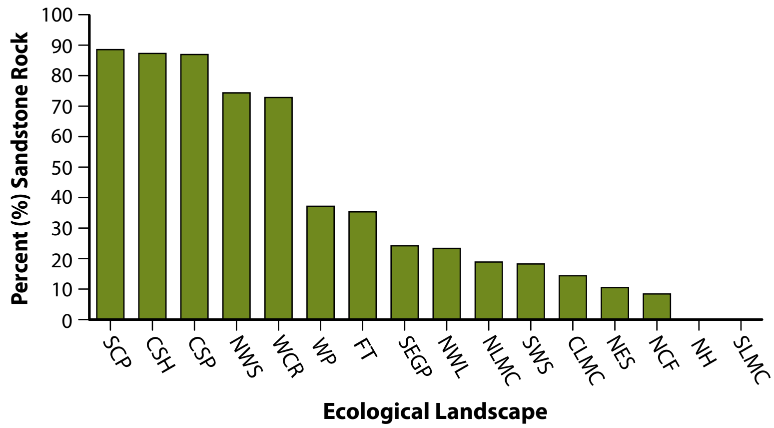


Figure 3.12. *Percentage of sandstone in the ecological landscapes of Wisconsin. Data from Wisconsin Geological and Natural History Survey. (See Table 3.1 for key to abbreviations.)*

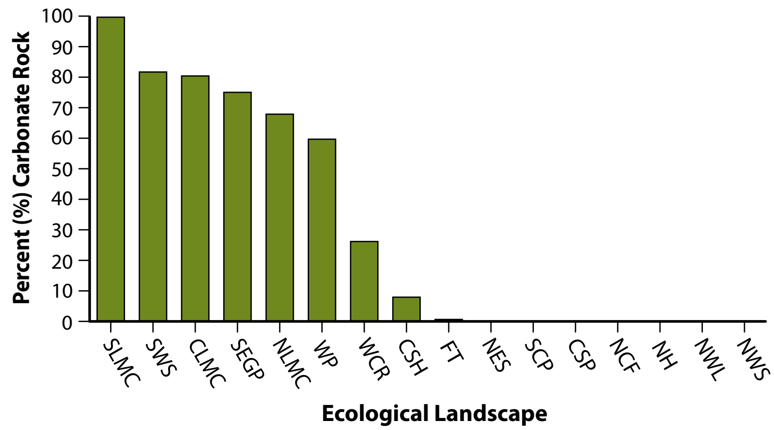


Figure 3.13. *Percentage of carbonate rock in the ecological landscapes of Wisconsin. Data from Wisconsin Geological and Natural History Survey. (See Table 3.1 for key to abbreviations.)*

Lakes underlain by carbonate rock can be fertile and very productive, affecting the types and abundance of aquatic plants and animals occurring there. A ready source of calcium, whether from bedrock, glacial till, soil, or groundwater, is a key element that affects the distribution of certain plants and invertebrates. Among the latter, land snails, freshwater mussels, and crayfish are especially important. Natural communities such as the Calcareous Fen are dependent on an internal source of calcium-enriched water.

Landforms and Glacial Geology

Multiple glaciations covered the area that is now Wisconsin during the Pleistocene epoch of the past 2.5 million years. The most recent glacial cycle, the Wisconsin glaciation, began about 70,000 years ago. Glacial ice advanced and retreated a number of times, with the final advance into our area beginning during the Late Wisconsin about 26,000 years ago. The ice sheet reached its maximum about 16,000 years ago (Figure 3.14) and then began melting, finally receding into Upper Michigan approximately 9,500 years ago (WGNHS 2010).

The direction that the ice sheet took as it moved through what is now

Wisconsin was due in part to the shape of the land surface and the type of bedrock. The Superior, Chippewa, Wisconsin Valley, and Langlade ***lobes*** covered northern Wisconsin, directed in part by the resistant igneous and metamorphic bedrock. The Lake Michigan lobe flowed through lowlands in what is now Lake Michigan, reaching as far as central Indiana and Illinois. The Green Bay lobe flowed through the Green Bay lowland and continued advancing south and west, eventually covering much of eastern Wisconsin (WGNHS 2010).

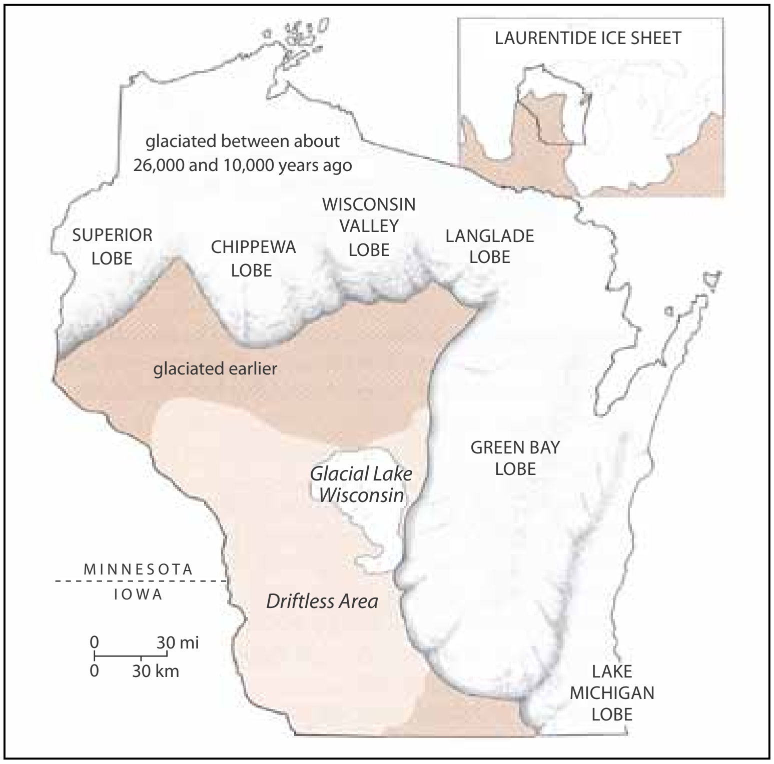


Figure 3.14. *Maximum extent of glacial ice during the Late Wisconsin advance, about 20,000 years ago. Glaciation that occurred more than 30,000 years ago covered an additional area in central Wisconsin. Source: Wisconsin Geological and Natural History Survey.*

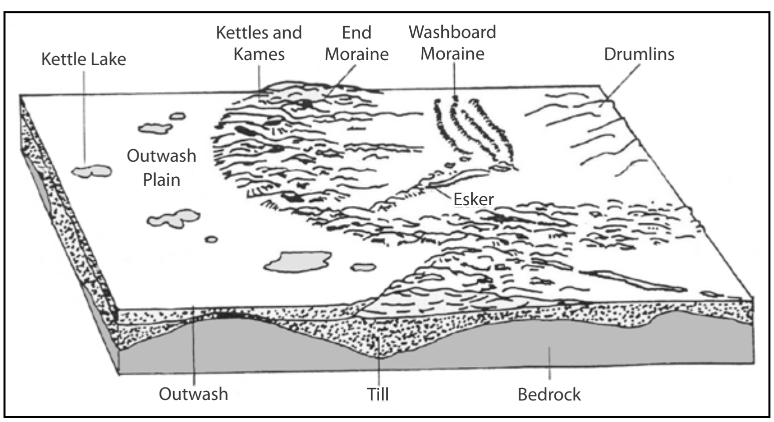


Figure 3.15. *A diagram of glacial landforms showing where an ice sheet advanced from right to left. The end moraine marks the maximum extent of glacial movement, with outwash covering the land surface in front of the glacier and a variety of landforms on the area formerly covered by the ice sheet.*

The landforms of Wisconsin were dominantly created by glaciers. Only two ecological landscapes, the Southwest Savanna and most of the Western Coulees and Ridges, are considered to have been unglaciated during the Pleistocene. Extensive glacial landforms are ***ground moraines***, ***end moraines***, outwash, and ***glacial lake deposits*** (see Figure 3.15). Additional glacial landforms include drumlins, ***eskers***, kames, ***kettles***, ***ice-walled lake plains***, ***tunnel channel outlets***, ***heads-of-outwash***, and outwash terraces and ***fans***. The sizes and shapes of these landforms, along with the character of the glacial materials that formed them, have a strong influence on ecosystem development in our area.

Ground Moraines

Ground moraines, also known as till plains, are areas of relatively low ***relief***, deposited beneath glacial ice as lodgment till or on top of glacial ice as ablation till. Lodgment till is typically loamy and is found at or near the surface throughout much of Wisconsin. It is often compacted and dense from the weight of the glacier, and in some places it impedes infiltration of water and creates wetlands. Ground moraines occur throughout the state (except in the unglaciated area) but are most common in the North Central Forest, Western Prairie, Northwest Lowlands, Forest Transition, Southeast Glacial Plains, Central Lake Michigan Coastal, Southern Lake Michigan Coastal, and Northern Lake Michigan Coastal ecological landscapes. Ground moraines are also common in the Superior Coastal Plain, but here they are formed of different material, typically clayey lacustrine sediment that glaciers pushed up from the Lake Superior basin. The surfaces of till plains deposited by earlier glaciations prior to 30,000 years ago have been modified by erosion and meltwater from Pleistocene glaciers or covered in outwash materials. This older till is at or near the surface in much of the Western Prairie and Forest Transition ecological landscapes, and in the northernmost parts of the Central Sand Plains and Western Coulees and Ridges ecological landscapes.

Drumlins are elongated hills that occur on some ground moraines, formed beneath a moving ice sheet. Wisconsin has some extensive drumlin fields, including a large one said to be one of the world's most outstanding examples (Schultz 2004). It formed under the southern part of the Green Bay lobe in eastern Dane, Jefferson, and Dodge counties and parts of Columbia and Fond du Lac counties. The long axis of drumlins formed parallel to the direction an ice sheet was moving, and the orientation of the drumlin field shows how the ice fanned out at the margins of the lobe. Other drumlin fields are located on ground moraines in northern Wisconsin.

End Moraines

End moraines develop at the margins of glaciers. A ridge of sediment is deposited during times when ice accumulation is approximately equal to ice loss due to melting, and the ice margin remains relatively stationary. End moraines can be insignificant ridges or can be impressive ranges of hills (e.g., Irma Hill on Highway I-39 south of Tomahawk), depending on the rate at which the ice sheet melted and the amount of sediment it was carrying at the time. ***Morainal ridges*** are typically discontinuous, with gaps where meltwater streams exited, places where the glacier carried little sediment, or places where the glacier had already melted away. Many end moraines have ***hummocky surfaces*** due to the uneven deposition of ***supraglacial till*** (sediment carried on top of an ice sheet). "Kettle" features also occur in end moraines where remnant blocks of stagnant ice slowly melted after the main ice margin had retreated. Sediment deposited around and over them gradually collapsed into a bowl-shaped cavity to form a kettle. Many notable kettles occur in the Kettle Moraine in the Southeast Glacial Plains Ecological Landscape. End moraines are most common in the Southeast Glacial Plains, Southern Lake Michigan Coastal, Central Lake Michigan Coastal, Central Sand Hills, Forest Transition, North Central Forest, Northern Highland, and Northeast Sands ecological landscapes (see the "End Moraine Deposits" map in Appendix H, "Statewide Maps," in Part 3 of the handbook, "Supporting Materials").

Outwash Deposits

Outwash deposits are formed when sand and gravel is carried away from a melting ice sheet by flowing meltwater. The heavier gravel and sand materials settle out of meltwater first, forming broad plains or fans in close proximity to the glacier, but clays, silts, and fine sands are typically carried for some distance in meltwater. This process results in large amounts of silt deposition in slow-moving ***braided streams***, and after the glaciers are gone and the land dries, silt is windblown and redeposited as loess. Outwash deposits are most common in the Northwest Sands, Northern Highland, and Northeast Sands ecological landscapes.

Pieces of ice frequently break off the edge of a melting glacier and are buried in outwash material. When the ice melts, outwash sand and gravel surrounds the depression formerly occupied by ice, creating a kettle. Many areas in Wisconsin contain outwash with ***kettles***, known as ***pitted (or collapsed) outwash***, and if the water table is high enough, ***kettle lakes*** form in these depressions. The high lake density of the Northern Highland Ecological Landscape is due in large part to the formation and abundance of kettles in collapsed outwash. Kettle lakes are also found in the Northwest Sands Ecological Landscape. The Northeast Sands is another ecological landscape that is dominantly an outwash landform, as are parts of the Central Sand Plains Ecological Landscape (although much of the latter is made up of sands that were deposited in Glacial Lake Wisconsin as outwash and then redeposited as lacustrine sand).

Heads-of-outwash are a distinctive feature formed at recessional positions of an ice sheet that is melting and thinning rapidly. Under these conditions, melting occurs so fast that outwash sand and gravel are piled up at the ice margin, and when the ice sheet has melted away, a "head-of-outwash" ridge remains. The Northeast Sands Ecological Landscape has Wisconsin's best examples of these landforms, but they are difficult to distinguish from morainal ridges, which often have similar shapes and sizes. However, the vegetation on an outwash head is generally of types characteristic of dry sandy soils, while moraines support more mesic vegetation.

Glacial Lake Deposits

Glacial lakes are common features during periods of glaciation. Most are small and transient when water is ponded on top of the ice or behind a morainal ridge, but several in Wisconsin were notable for their size and longevity and their lasting influence on ecosystems. Glacial Lake Wisconsin was the largest of the glacial lakes, occupying much of the Central Sand Plains Ecological Landscape at its maximum extent. This lake existed at various sizes and elevations from about 19,000 to 14,000 years ago, draining catastrophically when an ice dam at the east end of the Baraboo Hills weakened due to melting and then burst. The drainage of this glacial lake carved the picturesque sandstone walls along the Wisconsin River at Wisconsin Dells (Clayton and Attig 1989). Sediments left by Glacial Lake Wisconsin are primarily sandy at the surface because of the influx of outwash materials from melting glaciers during the latter part of its existence, but silty and clayey sediments typical of large glacial lakes underlie the sands. Another major lake, Glacial Lake Oshkosh, formed several times when the ice sheet stood in the Fox River lowland northeast of present-day Lake Winnebago and blocked drainage to Green Bay. Water became ponded in the area of the Fox River Valley until finding other outlets to Lake Michigan or to the Wisconsin River. Sediments of Glacial Lake Oshkosh are silts and clays.

Several postglacial lakes existed in the Lake Michigan basin as the ice sheet retreated. Lake Chicago formed in the southern part of the Lake Michigan basin at around 12,800 years ago while the shrinking ice sheet still occupied the northern part of the basin. Lake Chicago shorelines had three stages, with the highest level about 55 feet above current lake levels. Its shorelines have been identified in the Southern Lake Michigan Coastal Ecological Landscape (Martin 1965). Around 11,000 years ago, ***Lake Algonquin*** occupied the basins of Lakes Michigan and Huron, with water levels about 20 feet higher than the present lakes. The ***Nipissing Great Lakes*** formed about 5,000 years ago when

crustal rebound closed outlets to the north and water levels again rose to about 20 feet higher than present. Shoreline features of Lake Algonquin are not seen in the Southern Lake Michigan Coastal, likely having been cut away by Nipissing or Lake Michigan waters, but Nipissing shorelines are evident in some places (Martin 1965).

Postglacial rebound is gradually lifting the surface of the earth's crust in areas that were compressed by the weight of ice sheets during the Wisconsin glaciation. As a result, former shorelines of Lake Algonquin and Lake Nipissing are separated and more visible to the north, especially along the Door Peninsula, where crustal rebound raised the Lake Algonquin shorelines before the Nipissing lakes existed (Dott and Attig 2004). The Lake Algonquin beach is found at increasingly higher elevations to the north—it is 29 feet above Lake Michigan at the northwest edge of Green Bay and 40 feet at Oconto, indicating the extent of crustal rebound (Martin 1965). A sandy lake plain deposited by Glacial Lake Nipissing is located near Marinette in the Northern Lake Michigan Coastal Ecological Landscape, with shorelines of Glacial Lake Algonquin evident at elevations slightly above the lake plain. Landforms shaped by glacial lakes often exhibit features such as ridge-and-swale topography, beach and lake dune communities, ***sandspits***, and wave-cut clay bluffs and cliffs.

Postglacial lakes also existed in the Lake Superior basin. Glacial Lake Duluth began as a small lake in front of the melting ice sheet and enlarged as the ice retreated eastward and exposed more of the Lake Superior basin. Eventually, Lake Duluth was more than a third the size of Lake Superior (Martin 1965). Its drainage outlet was through what are now the Brule and St. Croix River valleys because, at that time, drainages to the east were blocked by ice. Shoreline deposits from the highest levels of Glacial Lake Duluth, around 9,900 years ago, are evident at elevations of about 886 to 1,082 feet along the southern boundary of the Superior Coastal Plain Ecological Landscape. A Nipissing beach is also evident at about 10 feet above the current level of Lake Superior (Clayton 1984). Crustal rebound is raising the eastern end of Lake Superior more rapidly than the western end by about 20 inches each century (Lee and Southam 1994). The differential rebound makes the land area near the city of Superior appear to be sinking and creates features such as the St. Louis River estuary, a ***"drowned" river mouth*** with extensive estuarine wetlands. Freshwater estuaries are prominent and ecologically important features along Wisconsin's Lake Superior coast.

Examples of Glacial Landforms

Notable examples of glacial landforms include the pitted outwash and kettle lakes of the Northern Highland, the extensive sandy outwash plains of the Northwest Sands, the former lakebed of Glacial Lake Wisconsin (Central Sand Plains), the Kettle Moraine (Southeast Glacial Plains), Johnstown Moraine (primarily in the Southeast Glacial Plains and Central Sand Hills), the Harrison Hills, in the Perkinstown End Moraine system, and the Winegar Moraine, an end moraine in the North Central Forest (see the "End Moraine Deposits" map in Appendix H, "Statewide Maps," in Part 3 of the handbook).

Many smaller-scale glacial features are common throughout the state and are discussed in more detail in the ecological landscape chapters. Most ecological landscapes have a variety of landforms and glacial sediments, but some are dominated by a specific type of deposit. For example, outwash sands are prominent in the Northwest Sands, Northeast Sands, and Northern Highland ecological landscapes and to a lesser extent in the North Central Forest, Forest Transition, Central Sand Plains, and Central Sand Hills ecological landscapes.

Although most of the state (except in the unglaciated areas) is blanketed with glacial sediments, bedrock still affects many landforms as either outcrops or as a base underneath the overlying glacial materials. Large outcrops of igneous or metamorphic rock that influence the landforms of the state occur in the Penokee Range, the Baraboo Hills, Blue Hills, McCaslin Mountain, Rib Mountain, and at scattered locations throughout Wisconsin. Important outcrops of limestone and dolomite occur along the Niagara Escarpment in eastern Wisconsin, and there are numerous outcrops of sandstone and dolomite in southwestern Wisconsin's unglaciated (driftless) area. Isolated sandstone outcrops occur as steep-sided flat-topped buttes in central Wisconsin, as a ***cuesta*** at the edge of and throughout the Driftless Area, and in northwestern Wisconsin.

Topography and Elevation

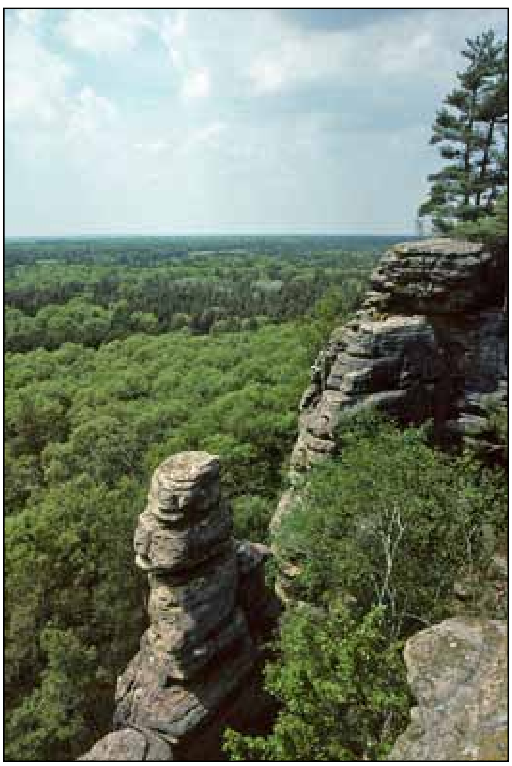
The topography of Wisconsin is strongly related to glaciation. Areas with nearly level topography (slopes 0%–3%) make up around one-third of the state; these flat areas are typically outwash plains and lake plains (Hole 1976). Moraines and till plains are generally undulating to rolling, and they make up over half the land area. Parts of end moraines can also have hilly topography, as is evident in the Winegar Moraine, the Harrison Hills, the Perkinstown Moraine, and the Kettle Moraine. Hilly and steep areas are common in the unglaciated region of southwest Wisconsin, where erosion over millions of years has created a dissected landscape (Western Coulees and Ridges and Southwest Savanna ecological landscapes). Hilly and steep topography also occurs in areas where bedrock has a strong influence on landform, such as the Baraboo Hills and Blue Hills. Some of these variations in topography around Wisconsin are evident in Figure 3.16. See the "End Moraine Deposits" map in Appendix H, "Statewide Maps," in Part 3 of the handbook.

Elevations within the state range from 577 feet along the Lake Michigan Coast (NOAA 2012) to 1,951 feet at Timm's Hill in the North Central Forest Ecological Landscape (Table 3.3). Elevations are generally higher in the north central part of the state, where igneous and metamorphic bedrock rises in the "***Wisconsin dome***," which is part of the ***Precambrian***

Shield, centered beneath the Northern Highland Ecological Landscape. The elevation of Lake Michigan is 577 feet and Lake Superior is slightly higher at 601 feet.

Local relief in the state is greatest in the Wausau area (Forest Transition Ecological Landscape), with an elevation difference of around 700 feet between the top of Rib Mountain (1,924 feet) and the Wisconsin River (around 1,190 feet). Another spot with high local relief is Wyalusing State Park in the Western Coulees and Ridges Ecological Landscape, where dolomite and sandstone-cored bluffs rise over the confluence of the Wisconsin and Mississippi rivers with an elevation difference of nearly 600 feet (Hole 1976). Local relief is very slight in other places, notably in lake plains of former Glacial Lake Wisconsin (Central Sand Plains Ecological Landscape) and Glacial Lake Oshkosh (Central Sand Hills and Southeast Glacial Plains ecological landscapes). End moraine landscapes may have up to 300 feet of local relief, and ground moraines (till plains) are typically at around 50 feet.

Figure 3.16. *Landforms of Wisconsin. Source: Wisconsin Geological and Natural History Survey.*



Sandstone cliffs at Quincy Bluff and Wetlands State Natural Area from atop Lone Rock, an excellent example of a Driftless Area mesa. Photo by Thomas Meyer, Wisconsin DNR.

Table 3.3. *High and low elevations and relief of ecological landscapes.*

	Surface elevation (ft. above sea level)		
Ecological landscape	**Low**	**High**	**Relief**
Central Lake Michigan Coastal	577	1,020	439
Central Sand Hills	738	1,316	578
Central Sand Plains	722	1,378	656
Forest Transition	682	1,924	1,234
North Central Forest	814	1,951	1,137
Northeast Sands	640	1,536	896
Northern Highland	1,394	1,864	470
Northern Lake Michigan Coastal	577	1,161	580
Northwest Lowlands	742	1,362	620
Northwest Sands	764	1,460	696
Southeast Glacial Plains	686	1,326	640
Southern Lake Michigan Coastal	577	978	397
Southwest Savanna	669	1,700	1,031
Superior Coastal Plain	601	1,408	821
Western Coulees and Ridges	584	1,588	1,004
Western Prairie	653	1,326	673

Soils

Wisconsin's soils are diverse and are closely related to the glacial history of the state (see the "Soil Regions" map in Appendix H, "Statewide Maps," in Part 3 of the handbook). Soils in about a third of the state are derived from glacial tills. These are loamy soils of high fertility, some of them enriched by minerals that were incorporated as glacial ice sheets moved over sedimentary bedrock. About another third of the state's soils were formed in glacial outwash sands and gravels, and these are soils with low fertility and low water-holding capacity. About a tenth of the soils are derived from ***glacial lacustrine materials***, which may be sandy, silty, or clayey depending on the water depth at the time of deposition. Another tenth of the soils formed from weathered bedrock, typically from sedimentary rocks that are more easily worn away, including sandstone, limestone, and dolomite. Some soils from glacial origins became wind-deposited loess soils in the unglaciated Western Coulees and Ridges and Southwest Savanna ecological landscapes. The remainder are organic soils of peat or muck or mineral soils with a high water table (Hole 1976).

Most soils of northern Wisconsin were formed in loamy glacial tills, including the large North Central Forest Ecological Landscape. Despite the favorable soil textures, agriculture is not common in northern Wisconsin because of the short growing season and the acidic nature of most till soils in that part of the state. The loamy till soils of southern Wisconsin, enriched with minerals from the underlying dolomite (or in the tills deposited by glaciers), are typically in agricultural uses (Johnson et al. 1993). The best examples of deep, calcareous till soils are found in the Southeast Glacial Plains Ecological Landscape, but similar soils also make up parts of the Central Sand Hills, Central Lake Michigan Coastal, and Northern Lake Michigan Coastal ecological landscapes. Soils of the Driftless Area, in the Western Coulees and Ridges and the Southwest Savanna ecological landscapes, are mostly formed from weathered sedimentary rocks. These are soils with varying degrees of fertility depending on the type of bedrock, depth to bedrock, and slope position; soils formed in limestone or dolomite may be quite fertile, while weathered sandstone typically produces infertile, droughty soils. The Western Coulees and Ridges Ecological Landscape was covered in a thick layer of wind-deposited loess after glaciation, and where it still exists, the soils are fertile, but erosion has removed the loess from many of the steep slopes (Johnson et al. 1993). Several parts of the state have extensive areas of sandy soils that originated from glacial outwash deposits (Figure 3.17). These include the Northwest Sands Ecological Landscape, much of the Northern Highland and Northeast Sands ecological landscapes, and parts of the Central Sand Plains Ecological Landscape. Sandy ***lacustrine soils*** occur within parts of the Central Sand Plains Ecological Landscape in the area of the former Glacial Lake Wisconsin, where outwash sand pouring into the lake was redeposited in the lakebed as lacustrine sand. Silty and clayey materials were deposited by Glacial Lake Oshkosh in parts of the Central Sand Hills, Southeast Glacial Plains, and Central Lake Michigan Coastal ecological landscapes. The Superior Coastal Plain Ecological Landscape is largely made up of clayey lacustrine soils that were originally deposited from very deep water in Lake Superior and then moved by glacial ice to their current location—a process that has been described as spreading peanut butter over a very large loaf of bread. See Bockheim (undated) for an overview of the taxonomic classification of Wisconsin soils.

Loess is a wind-deposited silty soil layer that blankets most of the state at thicknesses ranging from a few inches up to around 16 feet near the Mississippi River Valley (see the "Soil Regions" map in Appendix H, "Statewide Maps," in Part 3 of the handbook). After glacial ice melted away and the land surface was not yet protected by vegetation, winds blew unimpeded. Wind picked up silt materials deposited along glacial meltwater streams, especially along the Mississippi River, and redeposited them as loess. Loess was not deposited evenly over Wisconsin but drifted and accumulated in some places and was later eroded away in others. Loess is fertile and has an ideal soil moisture capacity for plant and crop growth, and its presence throughout the state contributes to a high overall level of soil productivity. ***Ecoregions*** with climate and soils similar to those of Wisconsin are not common worldwide but do exist in parts of Poland and Germany, the Koreas, China, and Russia (Bailey 1996).

The thickness of soil that overlies bedrock varies depending on glacial (including loess deposits) and erosional history. Most of the state has deep soils, with 50 or more feet of glacial sediment over bedrock (see the "Depth to Bedrock" map in Appendix H, "Statewide Maps"). Exceptions include the Western Coulees and Ridges and Southwest Savanna ecological landscapes. The southwestern part of the state was not glaciated during at least the past 2.4 million years, and because of the long period of erosion, most of the area has shallow soils less than 5 feet deep. The glaciated parts of Wisconsin have sediments of varying thickness. In the Central Sand Plains Ecological Landscape in the former lakebed of Glacial Lake Wisconsin, over a third of the soils are less than 5 feet from bedrock; others fall into the 5 to 50 foot range. Some areas along the ***Niagara Escarpment*** in the Southeast Glacial Plains and Central Lake Michigan Coastal ecological landscapes and the Door County portion of the Northern Lake Michigan Coastal Ecological Landscape also have soil that is less than 5 feet to bedrock. Adjacent to them on either side of the Niagara Escarpment and along the east edge of the unglaciated area is a zone of glacial deposits from 5 to 50 feet thick. Other scattered locations throughout the state have shallow soils over rock or exposed bedrock, notably the Penokee Range, the Blue Hills, and the Baraboo Hills.

Soil characteristics have had a strong influence on land uses throughout human history. American Indian tribes preferentially utilized floodplain soils of southern Wisconsin for cultivating crops because these soils are both fertile

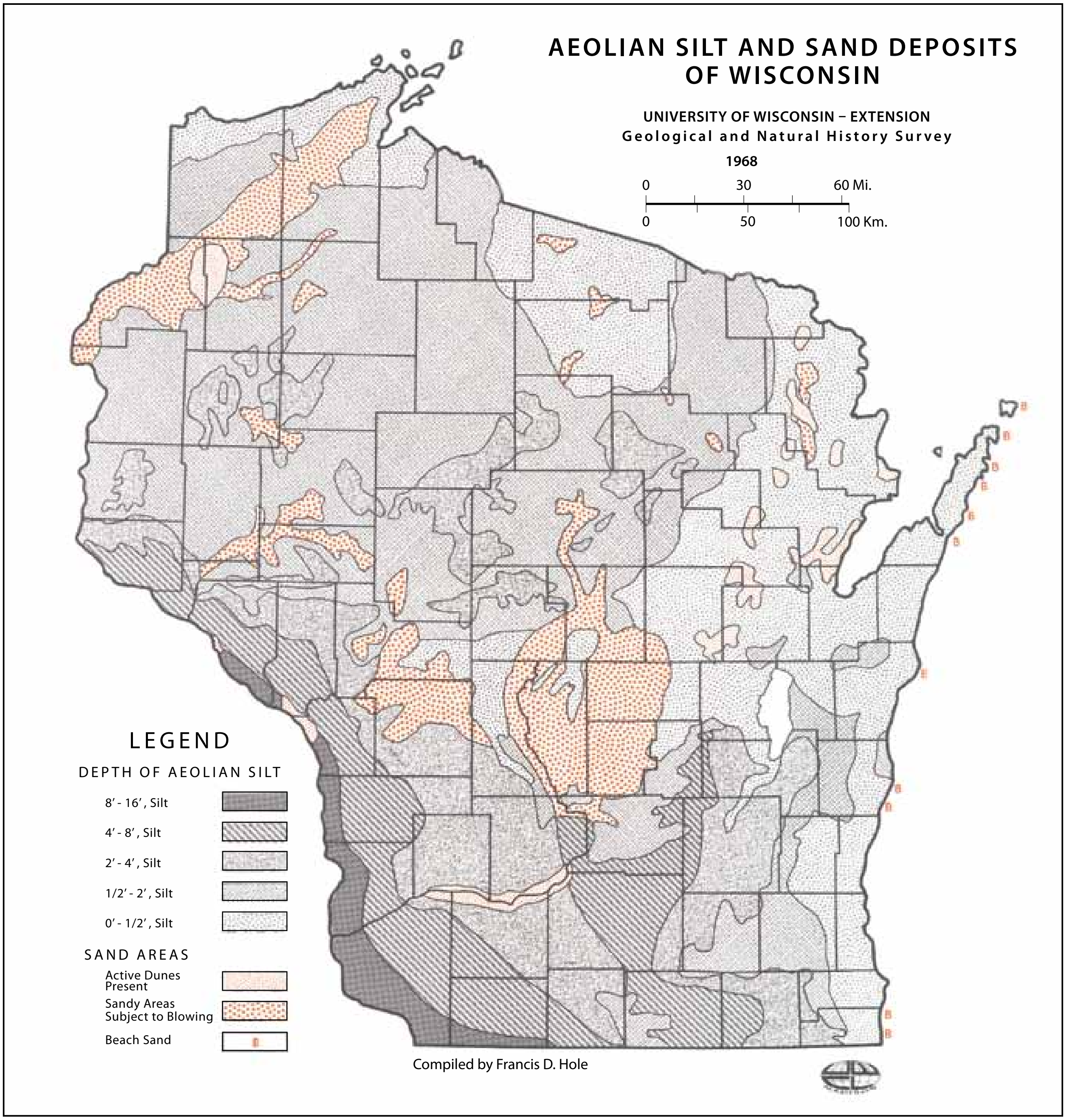


Figure 3.17. *Aeolian silt and sand deposits in Wisconsin. Hole, Francis D. Soils of Wisconsin. Copyrighted 1976 by the Board of Regents of the University of Wisconsin System. Reprinted courtesy of The University of Wisconsin Press.*

and easy to till. Euro-American immigrants during the 19th century cleared much of the forest and savanna and nearly all of the prairie land in southern Wisconsin and converted it to cropland or pasture. The most fertile areas, notably the Southeast Glacial Plains Ecological Landscape, remain in dominantly agricultural uses. Many areas within the Western Coulees and Ridges Ecological Landscape were less impacted due to the difficulty of farming in the rough, steep terrain. The infertile, excessively drained soils and extensive wetlands of the Central Sand Plains Ecological Landscape made that area less suitable for agriculture, and it is still among the least-developed parts of southern Wisconsin. Land conversion for agriculture was also less extensive in northern Wisconsin because of the colder climate and shorter growing season. Many areas where farming was unsuccessfully attempted have since reverted to forest.

Soil management issues in Wisconsin include the effects of development, agricultural practices, and forestry, among others. Excavation for development alters soil properties permanently because the fertile topsoil is removed or buried, and even if the site is reclaimed, it is unlikely that full productivity could be restored. Ongoing development on the best agricultural lands in the state, in the Southeast Glacial Plains Ecological Landscape and the ecological landscapes along Lake Michigan, is a concern for future food production. Chemical pesticides and fertilizers used in agriculture may leach into the groundwater in sandy soils, as atrazine has done in parts of Wisconsin, leading to areas where atrazine is prohibited by the Wisconsin Department of Agriculture, Trade, and Consumer Protection.

Agricultural equipment can cause physical damage to soils through compaction and rutting that decreases pore space in soils, thus decreasing water infiltration and aeration and limiting plant growth. No-till practices can reduce the number of passes that farm equipment must make, and this reduces the amount of compaction. Cropping systems that fail to utilize water conservation practices (such as contour farming and grass filter strips) contribute to erosion and sedimentation.

Forest management operations can also cause compaction and rutting, but these impacts can be limited if equipment travel is kept to designated routes, and wet conditions are avoided. There is a potential for some forestlands to become nutrient depleted if harvest removals occur too frequently and do not allow sufficient time for nutrients to accrue through atmospheric deposition and mineral weathering. This concern is primarily for soils that were formed in sandy outwash and lacustrine deposits and are inherently nutrient poor. Soils of the Superior Coastal Plain Ecological Landscape require special consideration because the fine-textured clays are often layered with sands, making soils particularly susceptible to erosion and slumping on cut banks along roads and streams. A large quantity of sediment can be transported to streams if these soils and watersheds are not managed carefully.

Aquatic Features

Basins

Wisconsin is a relatively water-rich state, with its glacial history contributing to the formation of a high diversity and abundance of waterbodies, wetlands, and groundwater storage areas. The state is divided into two major continental surface drainages—the Mississippi River drainage and the Great Lakes/St. Lawrence drainage. For water management purposes, the Wisconsin DNR further subdivides the Great Lakes drainage into the Lake Superior and Lake Michigan "major basins" and manages the entire Mississippi River drainage as a third "major basin" (Figure 3.18).

These three major basins are further divided into 24 "***water management units***," or water basins, which are hydrologically based. See the "Water Basins" map in Appendix H, "Statewide Maps" (in Part 3 of the handbook), which also shows the relationship of water basins to ecological landscapes. These water management units are further subdivided into 334 watersheds, which range from headwaters areas of small streams, to the larger tributaries and main stem segments of the state's largest rivers.

Great Lakes

Two Great Lakes border Wisconsin, Lake Michigan to the east and Lake Superior to the north, and provide approximately 1,000 miles of shoreline. State waters include 1.7 million acres of Lake Superior and 4.7 million acres of Lake Michigan, including Green Bay. Lake Superior borders the Superior Coastal Plain Ecological Landscape and Lake Michigan, including Green Bay, borders the Northern Lake Michigan Coastal, Central Lake Michigan Coastal, and Southern Lake Michigan Coastal ecological landscapes. The Great Lakes affect the local climate within these ecological landscapes and the plants and animals that occur there, providing specialized habitats for many rare plants and animals. For more details on the Great Lakes, see the "Aquatic Communities" section in Chapter 2, "Assessment of Current Conditions," and the individual ecological landscape chapters.

Inland Lakes

In Wisconsin, a "lake" or "pond" is any body of water that has a defined bed and banks but no discernable current. A "lake" can include a widening of a river characterized by the absence of any noticeable current from its inlet to its outlet. Such lakes are usually, but not always, created by a dam; for example, Lake Pepin, on the Mississippi River, is natural. A lake is considered an ***impoundment*** if one half or more of its maximum depth results from a dam or other type of control structure.

The *Wisconsin Lakes* book (Wisconsin DNR 2009c) lists 15,074 lakes, but due to the nature of the electronic mapping database, more than 500 of the lakes in that tally are in fact bays of the Great Lakes or other water features that are not "inland lakes" as defined in this handbook. In the Wisconsin DNR's Waterbody Assessment Tracking and Electronic Reporting System (WATERS) database, over 18,000 waterbodies are catalogued as "lakes," but again, many of these are small open waters that may be backwaters of large river systems. These riverine lakes may have characteristics of either lakes or rivers at different times of the year. Providing a definitive number of lakes is very difficult due to the complex nature of Wisconsin's hydrologic and vegetative features.

As of 2009, 14,531 lakes have been documented as meeting the definition given above, and this number is used for the number of lakes in Wisconsin. About 6,000 of these have been named. Most of the unnamed lakes are small (under 10 acres) and include floodplain and oxbow lakes along rivers and streams, small wildlife impoundments, and small bog lakes that may be part of expansive wetland complexes or occur in pitted glacial outwash landforms. Lakes as small as one acre and only a few feet deep have been named, but most small lakes are unnamed. These documented lakes cover a total of 982,075 acres, or about 2.76% of the state's surface area (Wisconsin DNR 2009c). Lake Winnebago (Winnebago County) is the largest inland lake by area (137,708 acres) and volume (696 billion gallons), and Green Lake (Big Green Lake) in Green Lake County is the deepest natural lake (236 feet). Lake Wazee, an abandoned iron mine in Jackson County, is the state's deepest man-made lake (355 feet).

Lakes vary by numerous characteristics, such as size, depth, configuration (shape), chemical characteristics (such as soft versus hard water), bottom materials, water clarity, or the types of plant and animal life present. For example, hard water lakes have higher levels of dissolved minerals such as calcium, iron, and magnesium than soft water lakes. Some lakes, especially those near acidic wetlands such as bogs, are stained with tannic acid that leaches from surrounding vegetation. The water in these "tannin lakes" may range in color from a dark brown "coffee" color to light brown.

Based on water source and outflows, four categories of lakes have been identified in Wisconsin (Wisconsin DNR 2009c):

1. ***Drainage lakes*** – These lakes have both an inlet and outlet where the main water source is stream drainage via the inlet. Most major rivers in Wisconsin have drainage lakes along their courses. An impoundment is considered a drainage lake since it has an inlet and outlet with its principal water source coming from stream drainage. Approximately 13% of Wisconsin's lakes are impoundments.

2. ***Seepage lakes*** – These lakes do not have an inlet or an outlet and only occasionally overflow. As landlocked waterbodies, the principal source of water is precipitation or overland flow (runoff), supplemented by groundwater from the immediate drainage area. Since seepage lakes commonly reflect groundwater levels and rainfall patterns, water levels may fluctuate seasonally. They may overflow in rare instances of unusually heavy precipitation or may dry up in response to drought. Groundwater pumping from high capacity wells can affect water levels in seepage lakes. In contrast to drainage lakes, landlocked seepage lakes are not connected by streams, which limits the interchange of aquatic species among them. Consequently, seepage lakes frequently have a less diverse fishery than drainage lakes. Seepage lakes also have a smaller drainage area or "lakeshed," which may help to account for lower nutrient levels. Seepage lakes are the most common lake type in Wisconsin and are especially characteristic of glacial landforms such as outwash plains.

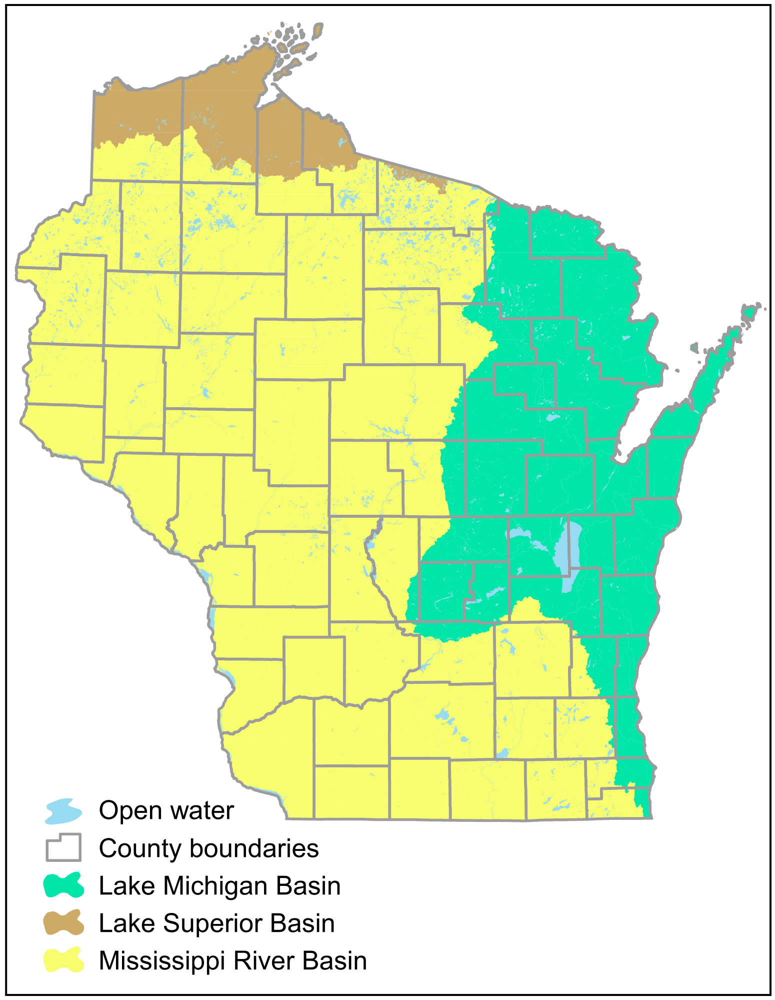


Figure 3.18. *Major water drainage areas in Wisconsin.*

3. ***Spring lakes*** – These lakes have no inlet, but they do have an outlet. The primary source of water for spring lakes is groundwater flowing into the bottom of the lake from inside and outside the immediate surface drainage area. Spring lakes are the headwaters of many streams and are a fairly common lake type in northern Wisconsin.

4. ***Drained lakes*** – These lakes have no inlet but, like spring lakes, have a continuously flowing outlet. Drained lakes are not groundwater-fed. Their primary source of water is from precipitation and direct drainage from the surrounding land. Frequently, the water levels in drained lakes will fluctuate depending on the supply of water. Under severe drought conditions, the outlets from drained lakes may become intermittent. Drained lakes are the least common major lake type found in Wisconsin.

For an example of how lake type and landscape position impact water clarity (as a stand-in for nutrient-related water quality), it is instructive to look at summer ***Secchi depth*** data. Shallow drainage lakes typically have the poorest water clarity (about 4 feet), while deep seepage lakes are generally the clearest (about 12 feet). For additional information on Wisconsin lakes, see the *Wisconsin Lakes* book (Wisconsin DNR 2009c).

Comparison of Lakes among Ecological Landscapes

The Northern Highland Ecological Landscape is recognized as one of the upper Midwest's most important areas for inland lakes and their associated natural communities (Table 3.4). Fifteen percent of the total number of lakes in the state and 16.8% of the named lakes occur in the Northern Highland Ecological Landscape. Lakes cover almost 10% of the surface area in the Northern Highland Ecological Landscape, more than twice the percentage of any other ecological landscape. Average lake size is 61 acres. A large proportion of the lakes over 50 acres in size are now heavily developed, especially in the vicinity of communities such as Minocqua, Eagle River, Three Lakes, Land O' Lakes, and Rhinelander. However, large blocks of state and federal forestlands surround and serve to limit development on some lakes, although many of these are smaller than 10 acres (often called ponds).

The much larger North Central Forest Ecological Landscape contains more than 5,000 total lakes, more than a third of the total number of lakes in the state (Table 3.4). It also holds nearly one-third of all the named lakes in Wisconsin. However, the average size of these lakes is only about 29 acres, and over 3,000 of them are unnamed (an indicator of very small size). The large base of public lands in the North Central Forest serves as a buffer against excessive development on some lakes, maintaining or preserving the potential for good aquatic and littoral habitat values and high water quality.

The Southeast Glacial Plains Ecological Landscape has the second highest percentage of its surface area in lakes (about 4.6%) (Table 3.4), and the highest average size of lakes (303 acres—indicating at least some are likely very desirable for development and attractive for motorized watercraft use) in the state, but very few of these lakes are protected by extensive public shoreline ownership (lakes in this ecological landscape include 137,000-acre Lake Winnebago, the Winnebago Pool lakes, and the Madison area lakes). Many are near growing population centers in Waukesha, Walworth, Kenosha, and Washington counties and have attracted intensive housing development. In addition, intensive agricultural use is characteristic of many parts of the Southeast Glacial Plains. Consequently, relatively few lakes in this ecological landscape exhibit good water quality and habitat values.

Lakes comprise about 4.5% of the Northwest Sands Ecological Landscape surface area (Table 3.4), but because of the proximity to the major population center of Minneapolis-St. Paul, many of these lakes are under heavy development pressure and are experiencing various levels of habitat loss or water quality degradation. However, large acreages of public lands partially protect shoreline habitats on some of these lakes from the negative ecological impacts associated with development.

Table 3.4. *Wisconsin inland lakes summary by ecological landscape.*

Ecological landscape	Total named lakes	Total unnamed lakes	Total lakes	Percent of total lakes	Area of all lakes (acres)	Ecological landscape area (acres)	Percent of EL in lakes
Central Lake Michigan Coastal	106	117	223	1.5	5,755	1,755,089	0.33
Central Sand Hills	296	168	464	3.2	22,126	1,388,705	1.59
Central Sand Plains	152	404	556	3.8	45,490	2,188,861	2.08
Forest Transition	923	1,125	2,048	14.3	65,280	4,658,498	1.40
North Central Forest	1,932	3,078	5,010	34.9	146,293	6,107,516	2.40
Northeast Sands	359	278	637	4.4	21,908	987,176	2.22
Northern Highland	1,058	1,116	2,174	15.0	133,093	1,331,970	9.99
Northern Lake Michigan Coastal	103	63	166	1.1	7,010	1,282,877	0.55
Northwest Lowlands	84	116	200	1.4	6,165	431,842	1.43
Northwest Sands	630	695	1,325	9.1	56,176	1,251,723	4.49
Southeast Glacial Plains	446	304	750	5.2	227,156	4,943,731	4.59
Southern Lake Michigan Coastal	81	32	113	0.8	6,917	539,830	1.28
Southwest Savanna	8	26	34	0.2	483	1,248,126	0.04
Superior Coastal Plain	31	72	103	0.7	3,603	905,929	0.40
Western Coulees and Ridges	195	403	598	4.1	29,788	6,170,674	0.48
Western Prairie	58	72	130	0.9	6,105	697,633	0.88
State total	**6,462**	**8,069**	**14,531**	**100.6**	**783,348**	**35,890,180**	2.18[a]

Source: Data on lakes from Wisconsin DNR 24k Hydrography Geodatabase (Wisconsin DNR 2012a). Available online at http://dnr.wi.gov/maps/gis/datahydro.htm and also accessible via the Surface Water Data Viewer, http://dnr.wi.gov/, keyword "surface water." Data for ecological landscape area calculated from Wisconsin DNR GIS data.

[a]Percentage of state area that are lakes.

Rivers and Streams

Wisconsin has about 12,600 rivers and streams, with approximately 77,300 total stream miles. Over 37,300 miles of these stream miles are perennial waters (Wisconsin DNR 2008b) and the remainder (more than 40,000) are intermittent stream miles. For the purpose of this handbook, stream miles do not include the lake or impoundment portion of any stream. Even though the average annual rainfall of more than 30 inches is relatively uniform across the state, the density of perennial streams and rivers from one ecological landscape to another varies widely (Table 3.5). This is due to a variety of factors, including topography, soils, subsurface geology, glacial features or their absence, land cover, and land uses (including hydrological disruptions such as stream channelization, wetland drainage and wetland fill).

These factors may lead to more stream miles per unit of surface area in some ecological landscapes by virtue of there being more streams or by virtue of creating extensive meanders under certain physical conditions. This has an impact on the number of stream miles per square mile of land, or stream density. For example, the Superior Coastal Plain Ecological Landscape, with numerous streams that flow across the Lake Superior lowlands, supports 1.06 miles of perennial stream per square mile of land surface (Table 3.5). In contrast, the Western Prairie Ecological Landscape hosts only 0.23 miles of stream per square mile. The average stream density across the state is 0.67 miles per square mile.

Most of Wisconsin's large rivers (those with average flow rates of at least 40 cubic feet per second) flow through more than one ecological landscape. Generally, they have their headwaters in northern Wisconsin and flow south to join the Mississippi River or Lake Michigan. Waterbodies meeting this definition of "large river" include the following:

- Mississippi River (all stretches bordering Wisconsin)
- Wisconsin River below Tomahawk
- Chippewa River below the mouth of the Flambeau River
- St. Croix River below the mouth of the Clam River
- Fox River below the mouth of the Puchyan River and between Lake Winnebago and Green Bay
- Menominee River below the Highway 2/141 bridge
- Rock River below Lake Koshkonong
- Flambeau River below the confluence of its north and south forks
- Wolf River below Shiocton
- Black River in La Crosse County
- Red Cedar River below Menomonie

Warmwater rivers occur statewide and can be found in most ecological landscapes in the state. Warmwater rivers are flowing waters with maximum water temperatures greater than 25°C. They usually have watershed areas greater than 500 square miles and mean annual flow rates of more than 200 cubic feet per second. Warmwater rivers include large rivers such as the Mississippi, Wisconsin, Chippewa, St. Croix, Black, Menominee, Fox, Wolf, and Rock as well

Table 3.5. *Wisconsin stream miles and stream density by ecological landscape.*

Ecological landscape	Total stream miles[a]	Ecological landscape area (acres)	Ecological landscape area (sq. mi.)	Stream miles/sq. mi.	Stream density rank
Central Lake Michigan Coastal	1,474	1,755,089	2,742	0.54	11
Central Sand Hills	1,114	1,388,705	2,170	0.51	12
Central Sand Plains	2,690	2,188,861	3,420	0.79	4
Forest Transition	4,705	4,658,498	7,279	0.65	9
North Central Forest	7,003	6,107,516	9,543	0.76	5
Northeast Sands	1,317	987,176	1,542	0.85	3
Northern Highland	1,316	1,331,970	2,081	0.67	8
Northern Lake Michigan Coastal	860	1,282,877	2,004	0.43	15
Northwest Lowlands	500	431,842	675	0.74	6
Northwest Sands	995	1,251,723	1,956	0.51	13
Southeast Glacial Plains	4,461	4,943,731	7,725	0.58	10
Southern Lake Michigan Coastal	421	539,830	843	0.50	14
Southwest Savanna	1,858	1,248,126	1,950	0.95	2
Superior Coastal Plain	1,496	905,929	1,416	1.06	1
Western Coulees and Ridges	6,849	6,170,674	9,642	0.71	7
Western Prairie	249	697,633	1,090	0.23	16
State total	**37,308**	**35,890,180**	**56,078**	0.67[b]	

Source: Data on streams from Wisconsin DNR 24k Hydrography Geodatabase (Wisconsin DNR 2012a). Available online at http://dnr.wi.gov/maps/gis/datahydro.htm and also accessible via the Surface Water Data Viewer, http://dnr.wi.gov/, keyword "surface water." Data for ecological landscape area calculated from Wisconsin DNR GIS data.

[a]Total stream miles does not include portions of streams that pass through lakes, impoundments, ditches, canals, or cranberry bogs. Total stream miles mapped on the Surface Water Data Viewer does not yet include approximately half of all documented intermittent streams.
[b]Stream miles per square mile for the entire state.

as smaller rivers such as the Sugar, Baraboo, Milwaukee, Flambeau, "northern" Yellow (Burnett County) and "central" Yellow (Wood and Juneau counties). A rich fish fauna, dominated by warmwater species such as true minnows (Cyprinidae), suckers (Catostomidae), catfishes (Ictaluridae), sunfishes (Centrarchidae), and perches, darters, and their relatives (Percidae) occur in these rivers (Wisconsin DNR 2008a).

Coldwater streams and rivers occur statewide and in many ecological landscapes, but high concentrations are found in the Northeast Sands, Central Sand Hills, Southwest Savanna, and Western Coulees and Ridges ecological landscapes. They are more numerous in the Northeast Sands and Central Sand Hills ecological landscapes because of glacial moraines that discharge cold ground water into streams. In the Western Coulees and Ridges and Southwest Savanna ecological landscapes, porous sedimentary bedrock (especially sandstones) discharges cold groundwater into the streams that occupy the numerous valleys of this highly dissected landscape.

Wetlands

For information on Wisconsin's wetlands, see the "Wetland Communities" section of Chapter 2, "Assessment of Current Conditions," and the "Vegetation and Land Cover" section of this chapter.

Springs and Spring Ponds

Seepages, springs, and spring ponds are the sources for many headwaters streams. They provide cold, well-oxygenated water that is essential to support coldwater assemblages, which include trout streams. Springs and spring ponds can provide essential habitat for a variety of common and rare species, including the Federally Endangered Hine's emerald dragonfly (*Somatochlora hineana*), which is partially dependent upon variability in spring flows for its survival. A recent compilation of historical and recent inventory data on Wisconsin springs documented 10,851 springs in the state (Macholl 2007) (Table 3.6).

There is a relationship between spring locations and Wisconsin's geological features. The unglaciated Southwest Savanna Ecological Landscape, especially in Grant County, contains the state's highest concentration of springs (1.3 per square mile) (Table 3.6). There are many small springs (less than 0.02 cubic feet per second) here that flow from pores or fractures in bedrock that is exposed or near the surface. The Western Coulees and Ridges Ecological Landscape has the next highest concentration of springs statewide, with about 0.44 springs per square mile. The Western Coulees and Ridges Ecological Landscape is especially rich in spring-fed coldwater streams.

The Northwest Lowlands Ecological Landscape has the fewest springs per unit area in the state, with only two documented (Table 3.6). While reports and comments from resource professionals note that more springs occur here (e.g., along the St. Croix River and some of its tributaries), these have not have been documented in the Wisconsin DNR's springs database.

The Superior Coastal Plain, Central Lake Michigan Coastal, and Northern Lake Michigan Coastal ecological landscapes also have very few documented springs, on the order of one per 100 square miles. This does not mean that springs are unimportant features in these or other ecological landscapes. For example, in the Northwest Sands Ecological Landscape, springs are highly localized, but they feed coldwater streams with important fisheries and other aquatic resources, including the upper Bois Brule River and many

Table 3.6. *Number and density of documented springs in Wisconsin by ecological landscape.*

Ecological landscape	No. of springs	Area (sq. mi.)	No. of springs/sq. mi.
Western Coulees and Ridges	4,232	9,642	0.44
Southwest Savanna	2,546	1,950	1.31
Southeast Glacial Plain	1,472	7,725	0.19
North Central Forest	800	9,543	0.08
Forest Transition	624	7,279	0.09
Central Sand Hills	265	2,170	0.12
Northern Highland	253	2,081	0.12
Northwest Sands	154	1,956	0.08
Central Sand Plains	133	3,420	0.04
Western Prairie	122	1,090	0.11
Northeast Sands	110	1,542	0.07
Central Lake Michigan Coastal	57	2,742	0.02
Southern Lake Michigan Coastal	49	843	0.06
Northern Lake Michigan Coastal	18	2,004	0.01
Superior Coastal Plain	14	1,416	0.01
Northwest Lowlands	2	675	0.003
State total	**10,851**	**56,078**	0.19[a]

Source: Data from Macholl (2007).

[a]Springs per square mile for the entire state.

streams that come out of the sands on the northern Bayfield Peninsula and flow to Lake Superior.

Springs in Wisconsin have been under threat from human activities that deplete, divert, or pollute their groundwater source, destroy the spring outlet, or reduce groundwater infiltration. Macholl (2007) estimated that only a few of the state's more than 10,000 springs are directly protected under the state groundwater quantity law (Wisconsin Act 310) because their flow rate exceeds one cubic foot per second. Thousands of important springs have flows below this legal threshold.

Ephemeral Ponds

Ephemeral ponds (also called "vernal pools") are isolated wetlands that occupy depressions in landscapes with impeded drainage and hold water for part of the growing season, usually following spring snowmelt and rains and sometimes following heavy precipitation events during the summer or fall. In most years they dry out by mid-summer. Because they are mappable waterbodies, ephemeral ponds are classified with lakes in the Wisconsin DNR's Natural Heritage Inventory. The "ephemeral" nature of these ponds makes them important for amphibians that breed successfully in fishless ponds and for specialized invertebrates such as fairy shrimp (Wisconsin has at least three species, all in the family of crustaceans known as the Chirocephalidae). Ephemeral ponds also support interesting assemblages of plants due to the unique conditions associated with the ponds and provide breeding, resting, and foraging habitat for many mammals, birds, and herptiles. Their ephemeral nature and unusual compositional, structural, and functional attributes differentiate them from permanent wetlands and other lake types.

Ephemeral ponds are important features in Wisconsin and are particularly common in the North Central Forest Ecological Landscape. Additional inventory work is needed to document the location, condition, and species assemblages associated with and at least partially dependent on these long-neglected features as they have not been given the attention they merit in most public property management plans. They present potentially important management opportunities in several other ecological landscapes, including the Forest Transition, Northern Lake Michigan Coastal, Central Lake Michigan Coastal, Forest Transition, Western Coulees and Ridges, Southeast Glacial Plains, and Southern Lake Michigan Coastal ecological landscapes and, perhaps, the Northern Highland.

In the Southeast Glacial Plains Ecological Landscape, a pilot project to identify and map potential ephemeral ponds was recently completed within the Milwaukee River Watershed (Wisconsin DNR 2009a). This project location was chosen because of the intensity of land development pressures there. This project is a step toward developing a means of identifying and mapping ephemeral ponds using both printed and electronic topographic maps as well as soil and other ancillary data that could be incorporated into a GIS database. Investigators focused on developing methods that are compatible with those used by the Wisconsin Wetland Inventory (WWI) in order to add ephemeral ponds to future WWI updates. This project found a great number of ephemeral ponds in the Milwaukee River watershed and points to a promising means of locating potential ephemeral ponds elsewhere. The project's insights, when refined, will prove useful in helping to produce a statewide inventory of ephemeral wetlands. It is expected to take quite a number of years beyond 2010 before Wisconsin DNR staff can initiate such an inventory project.

Groundwater

About two quadrillion (2,000,000,000,000,000) gallons of water are estimated to be stored underground in Wisconsin (Wisconsin DNR 1997). That is enough water to cover the state to a depth of 30 feet. Despite this abundance of groundwater, there is a growing concern in certain areas of the state about the quantity of good quality groundwater available for municipal, industrial, agricultural, and domestic use, and concern that there is adequate baseflow of groundwater to sustain our lakes, streams, and wetlands.

The state has more than 9,000 high capacity wells, and understanding how much water is used, by whom, and for what purpose is important for protecting the groundwater supply for all users. The U.S. Geological Survey estimated total groundwater use during 2005 to be 986 million gallons per day (Buchwald 2009). This estimate is 380 million gallons per day greater than withdrawals estimated for 1979 and 146 million gallons per day greater than those estimated for 2000 (Lawrence and Ellefson 1982, Ellefson et al. 2002).

Total groundwater use in 2005 can be divided into public-supply water use, as in water for various community uses delivered by a water-supply system (305 million gallons per day), and self-supplied water use, as in water withdrawn by a user and not obtained from a public supply (681 million gallons per day). Irrigation water use was the largest category of self-supplied use (387 million gallons per day), although the reported 2005 estimate was believed to be at the higher end of the range of possible irrigation water use.

In addition to the large regional areas experiencing adverse effects from groundwater withdrawals, such as in the northeastern and southeastern portions of the state, there are also cases of smaller, more localized areas of impact. Situations exist where wells, springs, and wetlands have gone dry; lake levels have dropped; and streamflow has been reduced, apparently in response to groundwater pumping.

In the Central Sand Plains and Central Sand Hills ecological landscapes, streamflows and lake (impoundment) levels appear to be depressed in a way not entirely attributable to recent climatic conditions. One case in particular, the Little Plover River, a Class I trout stream and Exceptional Resource Water in Portage County, has demonstrated the strong connection between groundwater and surface water. These two ecological landscapes have a large concentration of high capacity wells, and counties within the region are routinely among the highest in the state in regard to the amount of annual groundwater pumping. As a result of excessive groundwater withdrawal within its watershed, the Little Plover River has experienced dramatically reduced flows in the last few years to the point of completely drying up in stretches every year since 2005. Statistical approaches and groundwater flow modeling indicate that the Little Plover River would have continuous year-round flow in the absence of groundwater pumping in the area. The Little Plover River is just one example of diminished surface water resources in the Central Sand Plains Ecological Landscape—other headwaters streams are also exhibiting reduced flows, and a number of seepage lakes have experienced severely depressed lake levels over the past several years (G. Kraft, University of Wisconsin-Stevens Point, personal communication).

There is concern about the regional effect of groundwater withdrawals on some aquifers of the state. For example, concentrated pumping by multiple high capacity wells in southeastern Wisconsin and the Lower Fox River Valley (Figure 3.19) has raised concerns about the long-term effects of continued groundwater withdrawals from aquifers in these regions. There are also several examples of local-scale effects throughout the state

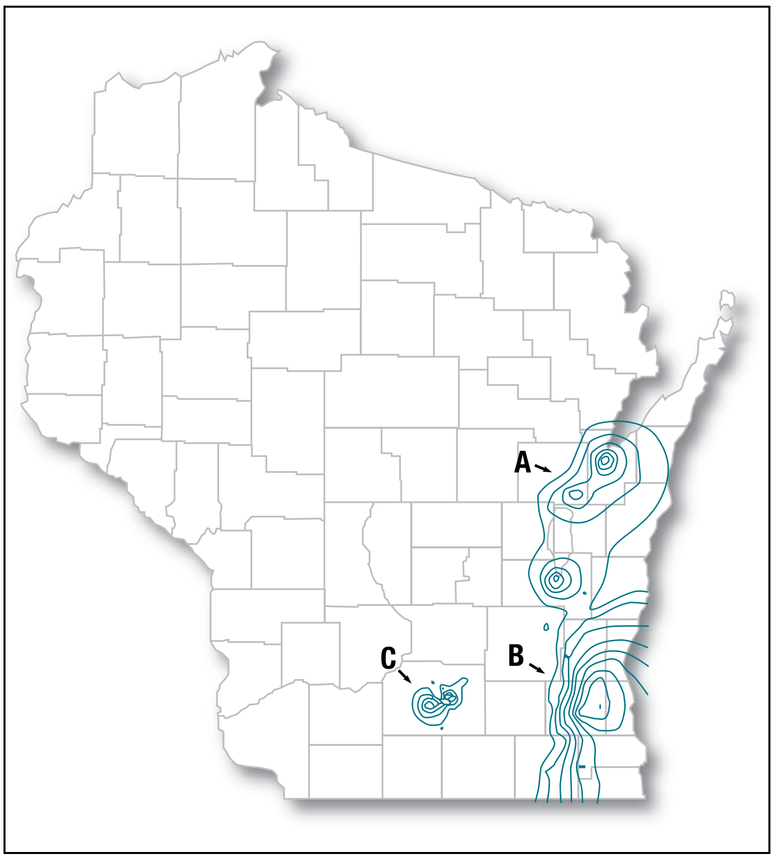


Figure 3.19. *Simulated drawdown of groundwater levels in southeastern Wisconsin resulting from groundwater pumping, 1998–2000. Contour intervals in Area A, 50 feet; in Area B, 50 feet; and in Area C, 10 feet. The maximum groundwater drawdown in Area A, the Lower Fox River Valley/Lake Winnebago Watershed, was projected as 336 feet; in Area B, southeastern Wisconsin, as 458 feet; and in Area C, Dane County, as 59 feet. Figure reproduced from a University of Wisconsin Water Resources Institute factsheet (WRI undated).*

from groundwater withdrawals by wells and ***groundwater dewatering operations***. There has been a long-term concern over the impact of groundwater withdrawals, particularly high capacity irrigation wells, on flow in the Little Plover River in central Wisconsin. Locally, groundwater levels in other areas have declined due to quarry and mining operation dewatering. There are also concerns about effects on streams and wetlands in southeastern Wisconsin due to groundwater withdrawals from nearby high capacity wells (Figure 3.20).

In some areas of the state, it is difficult to find an adequate supply of good quality groundwater. Parts of north central Wisconsin are underlain by fractured crystalline rocks that yield sufficient groundwater for domestic wells but not for large water supply wells. In some parts of the state, groundwater contains naturally occurring substances (e.g., sulfates, iron, chlorides, arsenic, radium) that limit its use. Human-caused contamination has reduced the water quality in several areas throughout the state, which limits the supply of or accessibility to good quality groundwater. Nitrates and pesticides are common groundwater contaminants caused by human uses in agricultural areas. Shallow aquifers tend to be more susceptible to human contaminants, whereas deeper aquifers are more likely to contain naturally occurring substances that impair water quality.

The state Groundwater Advisory Council developed rules and recommendations to obtain better data on how much groundwater is pumped out of Wisconsin aquifers, which took effect September 1, 2007. One of the benefits of these data will be to assure that trout streams and other high quality waters get groundwater in sufficient quantity and of the quality needed to sustain aquatic communities.

Surface Water Quality

Water quality in Wisconsin lakes and streams is highly variable. Water quality can vary radically within one watershed, depending on land use, land cover, soils, topography, and geological setting. While human activity often has the greatest impact on water quality, the condition of our state's waters is also a product of the natural conditions within each watershed, including geology, topography (landform), soils, and vegetation. Under requirements of the Clean Water Act, water quality across Wisconsin is summarized in a water quality report to Congress every two years (Wisconsin DNR 2010a).

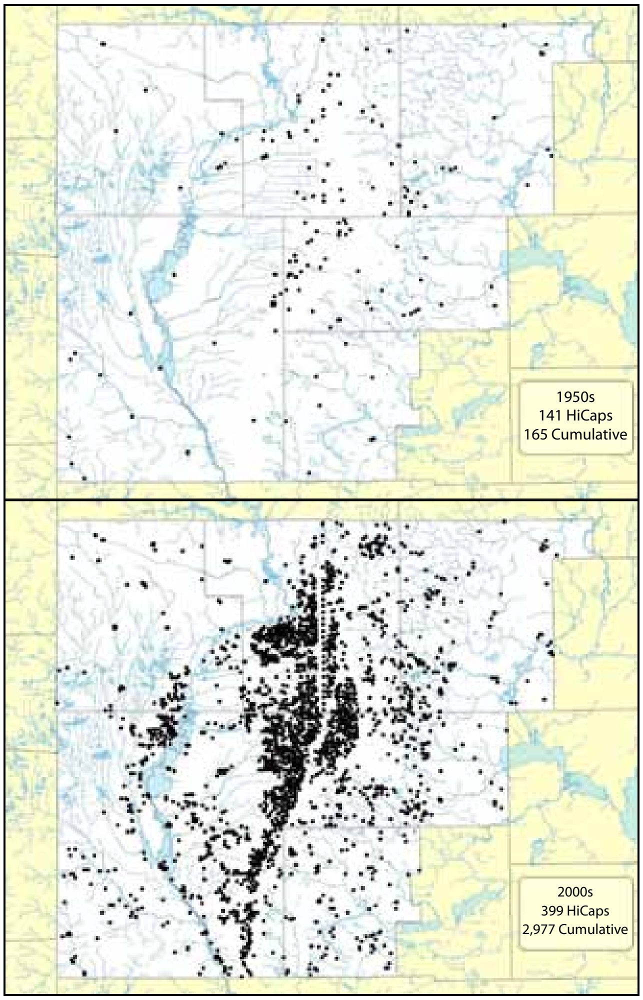


Figure 3.20. *The number of high capacity wells in central Wisconsin for the decade of the 1950s compared to the 2000s. Maps created by Dave Mechenich, Center for Watershed Science and Education, University of Wisconsin-Stevens Point.*

Water quality standards identify qualitative criteria such as taste, odor, or nuisance conditions, and they quantify specific allowable concentrations of dissolved oxygen and pollutants such as PCBs or mercury. A waterbody is polluted or "impaired" if it does not support full use by humans, wildlife, fish, and other aquatic life and if one or more of the qualitative or quantitative criteria of the Clean Water Act are not met. ***Impaired waters*** are placed on the Wisconsin DNR's Impaired Waters List (Wisconsin DNR 2012b), and actions proceed to reduce pollutants, which ends with delisting when water quality is restored.

From the 1970s thorough the 1990s, the requirements of the federal Clean Water Act have resulted in actions leading to significant improvements in water quality of Wisconsin's surface waters, especially regarding "end-of-pipe" ("point") discharges of industrial and municipal waste. Resource managers and landowners have also made improvements regarding ***nonpoint sources of pollution***, which includes an array of pollutants carried into lakes and streams by storm water runoff. These pollutants include excess nutrients (livestock and pet wastes, lawn and crop fertilizers), sediments (exposed soil at construction sites, bare fields, roadside ditches), pesticides (agricultural and residential), petroleum products, salt (from roadways and stockpiles), and metals (including cadmium, copper, cobalt, iron, nickel, lead, mercury and zinc from motor vehicles, roofs, and coal combustion). Pollutants originate from farmland, construction sites, cranberry operations, residential lots, commercial parking facilities, roadways, rooftops, electrical energy generation stations, and other sources. However, continual changes in agricultural practices present ongoing challenges, and nonpoint pollution remains a significant problem in both rural and urban areas.

Each of the 16 individual ecological landscape chapters includes a "Watershed Water Quality Summary" appendix showing the range of stream and lake water quality within each of its watersheds. The nature of water quality impairments is included in the tables. These tables reveal that land use is the critical factor in determining water quality. Within any given watershed among the 334 delineated in the state, streams in one drainage area can be of very high quality with little to no pollution while other drainages within the same watershed suffer impaired water quality due to local land use practices and sometimes from localized pollution discharges.

Overall, lakes and streams in watersheds that are the most forested or contain extensive wetlands tend to have the best water quality. Ecological landscapes that generally have the best overall water quality include the Northwest Sands, Northeast Sands, North Central Forest, Northwest Lowlands, and Northern Highland ecological landscapes (basically, those ecological landscapes with a high percentage of forest cover). However, at least some lakes and streams with high water quality occur within most ecological landscapes.

Lakes and streams that tend to have the poorest water quality are found in areas of heavy urban or rural residential development or in agricultural areas with practices conducive to high rates of soil erosion, grazing of stream banks, heavy use of fertilizers, or high concentrations of livestock (Wang et al. 1997). These lakes and streams are often officially designated as having impaired water quality that requires special action to meet water quality standards under the federal Clean Water Act. The Southern Lake Michigan Coastal Ecological Landscape has the lowest overall water quality due to the high levels of urbanization, other intensive land uses, and hydrological disruptions, including the channelization of streams for industrial and storm water conveyance and agricultural purposes. Most ***subwatersheds*** here have only poor to fair water quality.

Other ecological landscapes have watersheds with variable water quality, depending on land cover and land use impacts. Areas of forest, grassland, and wetland cover can attenuate the impacts of agricultural and moderate urban development.

Exceptional/Outstanding Resource Waters

Wisconsin has designated many of the state's highest quality waters as Outstanding Resource Waters (ORWs) or Exceptional Resource Waters (ERWs). Waters designated as ORW or ERW are surface waters that have good water quality, are not significantly impacted by human activities, provide outstanding recreational opportunities, and support valuable fisheries and wildlife habitat.

Ecological landscapes that are dominated by urban or agricultural land uses tend to have the fewest miles of ORW/ERW streams and the lowest number of occurrences of ORW/ERW lakes. The Central Lake Michigan Coastal, Central Sand Plains, Southern Lake Michigan Coastal, and Southwest Savanna ecological landscapes stand out in this regard, having few to no miles of designated ORW/ERW streams or acres of designated lakes (Table 3.7). This may be partly due to the nature of some of these ecological landscapes; for example, there are very few lakes in the Southwest Savanna and Central Sand Plains, and few lakes in the other ecological landscapes mentioned.

Far more ORW/ERW lakes and streams are present in areas with the least amount of ***impervious land surface*** (pavement, buildings, parking lots, or other developments from which water runs off of the surface immediately) and greater extent of forest, wetland, or grassland cover, including the Forest Transition, North Central Forest, Northeast Sands, Northern Highland, Northwest Lowlands, Northwest Sands, and Superior Coastal Plain ecological landscapes (Table 3.7). It is in these ecological landscapes where opportunities to

The Pike River in Marinette County is classified as an Outstanding Resource Water and is one of five river stretches formally classified as a "Wild River" by Wisconsin Statute. Photo by Brian Collins.

Table 3.7. *Outstanding and exceptional resource waters in the ecological landscapes of Wisconsin.*

Ecological landscape	ORW/ERW lakes[a]	ORW/ERW lake acres[a]	Percent ORW/ERW named lakes	ORW/ERW stream segments	ORW/ERW stream miles	ORW/ERW stream miles per 1,000 sq. mi.	Percent ORW/ERW stream miles
Central Lake Michigan Coastal	0	0	0.0	13	119	43.4	08.0
Central Sand Hills	12	1,093	4.1	63	299	137.8	26.6
Central Sand Plains	0	0	0.0	60	222	65.3	08.2
Forest Transition	29	12,281	3.1	422	1,722	236.5	35.5
North Central Forest	76	85,241	3.9	500	2,330	251.3	31.5
Northeast Sands	15	4,259	4.2	231	817	530.5	61.4
Northern Highland	41	37,135	3.9	73	368	186.8	23.8
Northern Lake Michigan Coastal	3	2,645	2.9	42	216	107.8	25.0
Northwest Lowlands	5	1,639	6.0	47	296	439.8	39.4
Northwest Sands	29	11,586	4.6	113	619	316.5	57.6
Southeast Glacial Plains	4	353	0.9	63	448	58.0	09.6
Southern Lake Michigan Coastal	0	0	0.0	0	0	0	0.0
Southwest Savanna	0	0	0.0	31	200	102.6	10.8
Superior Coastal Plain	3	311	9.7	95	556	392.9	37.2
Western Coulees and Ridges	5	445	2.6	253	1,210	125.6	17.9
Western Prairie	3	5004	5.2	17	147	134.8	57.0
State total					**9,569**		21.7[b]

[a]See Table 3.4 for lake totals.

[b]Percent of stream miles per square mile for the entire state (37,308 stream miles) that are ORW/ERW. (Total stream miles does not include portions of streams that pass through lakes, impoundments, ditches, canals, or cranberry bogs.)

protect and manage for high quality waters and aquatic communities are most highly concentrated. However, because aquatic communities differ across the state in many ways, it is also essential to protect the best remaining aquatic communities in those ecological landscapes that are more impacted by human activities if we are to conserve the full spectrum of aquatic resources native to Wisconsin.

The complete list of ORW/ERWs can be found on the Wisconsin DNR's web page for Outstanding and Exceptional Resource Waters (Wisconsin DNR 2009b). The designations are updated when staff resources allow, and any changes are noted in the DNR's biennial water quality report to Congress (Wisconsin DNR 2010a). The web page also includes updated information on the important designations.

Impaired Waters

Impaired waters (Clean Water Act 303(d) Waters) are lakes and streams with water quality that does not meet water quality standards set by the Environmental Protection Agency and which are considered impaired under the federal Clean Water Act. These waters are considered impaired due to the presence of various pollutants or other conditions that impact a waterbody's biological productivity or human uses (e.g., for drinking water, recreation, consumption of fish).

Among the 16 ecological landscapes in the state, those in the more forested northern third of Wisconsin have the fewest impaired waters because of their better overall water quality, including the Northwest Sands, North Central Forest, Northeast Sands, Northern Highland, and Northwest Lowlands ecological landscapes. A higher portion of watersheds here tend to have water quality in the very good to excellent range and very few in the fair to poor range (USGS 1995). However, some otherwise high quality waterbodies in northern ecological landscapes are included in the Wisconsin DNR's Impaired Waters List, most often because of high methyl mercury levels in sport fish tissue. Mercury tends to accumulate in fish in areas with natural wetlands because the wetlands support bacteria that convert mercury to methyl mercury, which enters the food chain through aquatic plants and small aquatic animals that have taken up the methyl mercury. Many northern lakes are also more susceptible to acidification than those in the east and southeast, so success in reducing acid precipitation may help reduce mercury in fish tissue.

Watersheds with higher percentages of land in agricultural and urban uses tend to have more water quality impairments and lower overall water quality. Ecological landscapes with a greater incidence of water pollution and more impaired waters include the Southeast Glacial Plains, Southern Lake Michigan Coastal, Southwest Savanna, and Western Prairie ecological landscapes. These areas tend to have large numbers of watersheds with streams in the fair to poor range and very few in the good to very good range. Dominant land uses in these areas are agricultural and/or urban/industrial.

***Top:** The Fox River has long been the site of large concentrations of paper mills and other industry. Large amounts of PCBs were released into the river from the mid-1950s through 1980, and now the river is the focus of the largest toxic sediment cleanup project in North America. **Bottom:** Dredged contaminated sediments from the river being dewatered prior to disposal. Photos by Wisconsin DNR staff.*

In the middle of the water quality spectrum, ecological landscapes such as the Central Sand Hills tend to have streams of more moderate water quality and more water quality variability within watersheds. More streams tend to have fair to good water quality, and fewer have either poor or very good to excellent water quality. These ecological landscapes tend to have mixtures of land cover and land uses of agriculture, forests, wetlands, and residential areas. Even in the ecological landscapes with more water quality degradation problems, there are watersheds and streams with good to very good water quality. In these watersheds, it is important to maintain high water quality standards and protect lakes and streams against further water quality degradation.

Ecological Characteristics

This section compares the vegetation, land cover and land use, and fauna that occur within the different ecological landscapes in the state, including comparisons of rare species, Species of Greatest Conservation Need, and responsibility species found among the ecological landscapes.

Vegetation and Land Cover

The following material discusses Wisconsin's past and present land cover. Major changes are attributed to settlement patterns and widespread land use changes from the mid-19th century to the present.

Historic Vegetation

Southern Wisconsin vegetation was primarily a mix of prairie, savanna, and hardwood forest (from dry to wet types) when Euro-American settlers arrived. The vegetation of the northern part of the state was primarily forest, with dry to wet forest types occurring across the landscape in a heterogeneous mix, although mesic northern hardwood or hemlock hardwood forests were by far the most abundant. Oak and pine barrens occurred on sandy outwash plains in the northwestern, northeastern, and central part of the state and on terraces (south of the Tension Zone) along some of the large rivers (e.g., Wisconsin, Chippewa, and Black rivers). Extensive floodplain forests were associated with most of the large rivers in southern and central Wisconsin. Wetlands were abundant and scattered throughout the state except in the unglaciated southwest where they were confined to large river floodplains. As Wisconsin was settled by Euro-Americans, the vegetation and land cover of the state changed dramatically.

For an estimate of the amount of Wisconsin occupied by the major native plant communities in the mid-1800s, see Table IV-2 in the appendix for Chapter 4 of *The Vegetation of Wisconsin* (Curtis 1959). Finley (1976) analyzed the General Land Office's Public Land Survey notes from the 1800s and created a large format 1:500,000 map titled "Original Vegetation of Wisconsin." D.J. Mladenoff and coworkers at the University of Wisconsin-Madison digitized the information found in the same notes that Finley used for his map and created a GIS dataset and map of vegetation present in Wisconsin during the mid-1800s (Mladenoff et al. 2009).

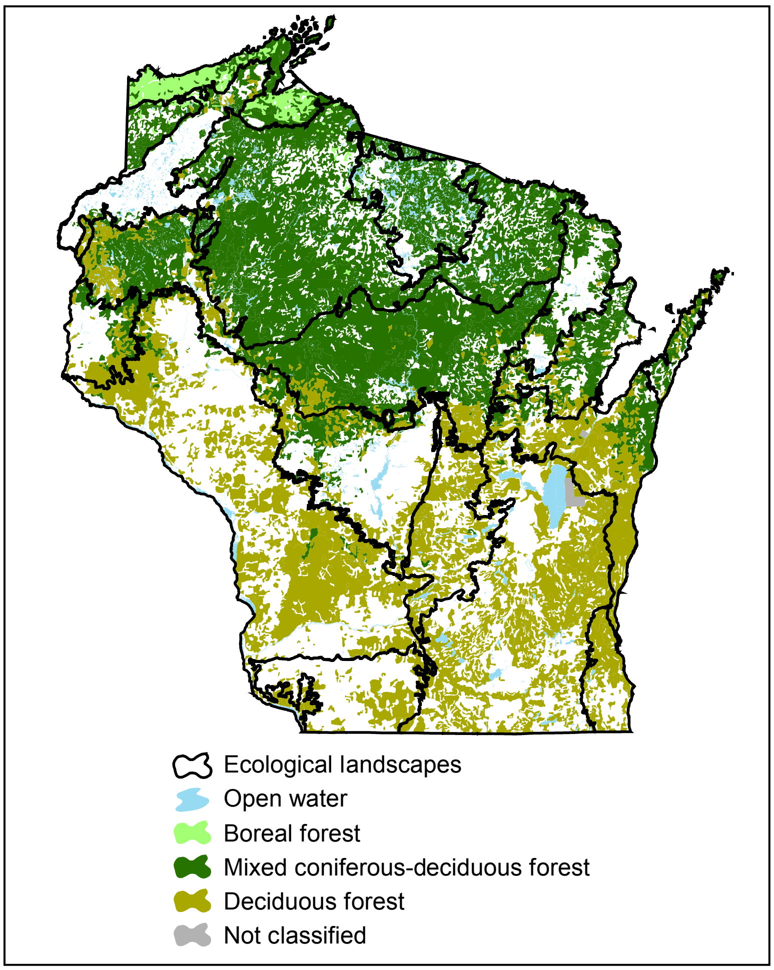


Figure 3.21. *Upland forest habitat at the time of Euro-American settlement, based on Finley's original vegetation classification.*

Forests

Historically, the forests in the southern part of the state (Province 222; see Figure 2.10 in Chapter 2) consisted mainly of deciduous species (Figure 3.21), with black oak (*Quercus velutina*), bur oak (*Q. macrocarpa*), and white oak (*Q. alba*) dominating the dryer areas and other hardwoods such as maples (*Acer* spp.), ashes (*Fraxinus* spp.), elms (*Ulmus* spp.), American basswood (*Tilia americana*), and red oak (*Q. rubra*) dominating the more mesic areas (Table 3.8). Based on the federal General Land Office Public Land Survey (PLS) ***witness tree*** data from the mid-1800s, the average ***Relative Importance Value (RIV)*** for all oak species in the seven ecological landscapes in Province 222 is over 64% (Table 3.9). According to Finley's interpretation of the PLS witness tree data (Finley 1976), ecosystems with significant oak components, including savannas, covered more than 62% of the land area of the seven ecological landscapes in Province 222 (Table 3.8).

Forests in the northern part of the state (Province 212; see Figure 2.17 in Chapter 2) were much more likely to be dominated by conifers or at least to have a conifer component (Figure 3.21, Table 3.8). According to PLS witness tree data, the tree species with the highest average RIVs across the nine ecological land-

Table 3.8. *Number of acres of vegetation cover types in each ecological landscape at Euro-American settlement times based on Finley's original vegetation classification. Numbers highlighted in red indicate the ecological landscape with the most acres of the given cover type. Acres in bold italic indicate the cover type with the largest number of acres within a given ecological landscape.*

	Province 212									Province 222							
Code[a]	CLMC	FT	NCF	NES	NH	NLMC	NWL	NWS	SCP	CSH	CSP	SEGP	SLMC	SWS	WCR	WP	Total
ABW/P	4,451	66,729	46,751	15,230	20,533	5,773	87,486	7,492	12,530	4,519	308	2,117	–	–	41,802	78,863	394,585
BE/O	***750,311***	3,917	1,323	16,972	–	181,067	–	–	–	–	–	273,059	69,825	–	452	–	1,296,926
BF	–	–	38,167	852	4,777	–	28,773	20,385	***450,835***	–	–	–	–	–	–	–	543,790
BHH/P	282,930	95,841	21,599	77,871	–	***474,495***	–	–	–	–	–	–	–	–	–	–	952,736
GG	2,301	16,508	–	–	–	–	–	–	2,403	49,234	18,910	606,403	91,541	400,601	320,439	***171,203***	1,679,542
GLS	14,142	12,406	–	–	7,602	10,330	374	19,190	4,650	178,625	193,899	584,287	41,607	13,778	103,301	929	1,185,119
HH/P	80,759	***1,737,584***	***3,569,742***	191,012	225,592	160,559	–	6,753	218,566	–	14,299	1,469	–	–	467	–	***6,206,802***
Hydro	9,029	87,065	176,670	25,095	161,572	8,534	5,891	54,963	4,614	41,612	66,309	253,314	7,051	658	120,881	9,033	1,032,291
LH	48,731	8,480	29	–	–	51	7,497	21,145	–	5,102	19,668	35,058	5,144	–	158,865	681	310,451
NH/O	224,477	353,176	34,939	3,640	–	11,482	37,566	7,528	–	8,764	23,969	926,785	***152,008***	38,915	1,123,124	161,882	3,108,253
NH/P	–	1,149,594	640,077	5,745	54,435	5,092	33,076	23,760	31,859	–	95,957	–	–	–	61,095	91,020	2,191,710
NI	5,373	–	–	–	–	–	–	–	666	–	–	44,733	–	–	2,406	–	53,177
OO	44,817	333,695	31,506	–	–	6,940	2,995	39,460	2,788	***779,929***	436,581	***1,198,497***	112,767	322,393	***1,652,181***	30,704	4,995,253
OS	19,527	8,084	–	–	–	1,243	–	–	504	270,067	99,987	805,000	50,834	***459,528***	1,630,092	70,180	3,415,047
PJ/OX	9,869	168,470	94,166	***287,607***	141,937	22,811	17,643	***783,594***	3,599	10,059	***572,496***	2,369	–	–	254,481	2,287	2,371,388
PW/PR	11,706	218,633	315,100	149,617	***456,725***	27,968	***106,666***	187,043	130,758	3,109	270,503	4,649	–	–	40,328	9,939	1,932,743
SC	239,128	373,134	1,124,634	199,296	254,692	342,613	96,587	73,671	32,809	18,815	372,074	187,037	8,643	–	49,080	2,310	3,374,524
UB	4,244	24,656	11,707	10,248	4,112	16,150	–	6,728	3,589	18,880	3,884	15,537	–	11,000	602,978	67,158	800,872

[a]**Code:**

Finley's classification

ABW/P	Aspen, white birch, pine
BE/O	Beech, sugar maple, basswood, red oak, white oak, black oak
BF	White spruce, balsam fir, tamarack, white cedar, white birch, aspen
BHH/P	Beech, hemlock, sugar maple, yellow birch, white pine, red pine
GG	Prairie
GLS	Marsh and sedge meadow, wet prairie, lowland shrubs
HH/P	Hemlock, sugar maple, yellow birch, white pine, red pine
Hydro	Water
LH	Lowland hardwoods – willow, soft maple, box elder, ash, elm, cottonwood, river birch
NH/O	Sugar maple, basswood, red oak, white oak, black oak
NH/P	Sugar maple, yellow birch, white pine, red pine
NI	Area with vegetation cover type not interpreted on the source map
OO	Oak – bur oak, white oak, black oak
OS	Oak openings – bur oak, white oak, black oak
PJ/OX	Jack pine, scrub oak, and barrens
PW/PR	White pine, red pine
SC	Swamp conifers – white cedar, black spruce, tamarack, hemlock
UB	Brush

Ecological landscapes

CLMC	Central Lake Michigan Coastal
CSH	Central Sand Hills
CSP	Central Sand Plains
FT	Forest Transition
NCF	North Central Forest
NES	Northeast Sands
NH	Northern Highland
NLMC	Northern Lake Michigan Coastal
NWL	Northwest Lowlands
NWS	Northwest Sands
SEGP	Southeast Glacial Plains
SLMC	Southern Lake Michigan Coastal
SWS	Southwest Savanna
SCP	Superior Coastal Plain
WCR	Western Coulees and Ridges
WP	Western Prairie

Table 3.9. *Relative Importance Values (RIV) for Public Land Survey witness trees by ecological landscape. A key to the abbreviation of ecological landscapes can be found in Table 3.8. Numbers highlighted in red indicate the ecological landscape with highest RIV for the given tree species. RIVs in bold italic indicate the tree species with the largest RIV within a given ecological landscape.*

	Province 212									Province 222						
Common name	**CLMC**	**FT**	**NCF**	**NES**	**NH**	**NLMC**	**NWL**	**NWS**	**SCP**	**CSH**	**CSP**	**SEGP**	**SLMC**	**SWS**	**WCR**	**WP**
OAKS																
Black oak	–	0.5%	–	–	–	–	–	–	–	***36.7%***	12.2%	13.5%	10.9%	10.9%	14.8%	7.9%
Bur oak	0.6%	1.5%	0.1%	0.1%	0.1%	0.1%	1.1%	0.7%	0.1%	25.3%	6.8%	***32.3%***	***29.0%***	36.2%	15.9%	11.6%
Pin oak	1.8%	0.5%	–	0.3%	–	0.2%	0.5%	2.2%	–	2.2%	1.1%	1.8%	0.5%	1.2%	3.2%	1.2%
Red oak	2.9%	2.5%	0.9%	1.6%	0.9%	1.1%	1.4%	0.8%	1.2%	0.3%	1.6%	1.7%	3.4%	2.3%	2.6%	1.0%
White oak	6.0%	3.9%	0.4%	0.6%	–	0.6%	2.1%	2.0%	–	29.1%	7.8%	21.9%	22.3%	***44.6%***	***33.6%***	12.9%
Hickory	0.3%	0.1%	–	–	–	–	–	–	–	0.5%	–	0.6%	1.0%	0.8%	0.8%	0.4%
PINES																
Jack pine	–	0.4%	0.3%	9.0%	1.7%	0.2%	3.1%	***30.8%***	0.3%	0.3%	12.9%	–	–	–	1.2%	–
Red pine	0.2%	1.6%	1.7%	14.4%	15.8%	1.3%	3.8%	28.7%	4.1%	0.2%	9.3%	0.1%	–	–	1.4%	–
White pine	7.2%	11.8%	11.7%	***22.2%***	***22.7%***	12.6%	***17.7%***	16.9%	***21.2%***	0.1%	***23.9%***	0.4%	–	–	2.2%	3.6%
Spruce pine	–	–	–	0.4%	1.4%	–	–	–	–	–	–	–	–	–	0.3%	–
FIR/SPRUCE																
Fir	0.1%	0.9%	2.9%	0.9%	1.2%	0.6%	4.6%	0.4%	5.0%	–	–	–	–	–	–	–
Spruce	0.1%	0.5%	3.0%	1.6%	5.1%	0.7%	7.5%	0.7%	9.7%	–	0.5%	–	–	–	–	–
NORTHERN HARDWOODS																
Ash	–	–	–	–	–	–	–	–	–	–	0.2%	0.1%	0.1%	–	0.6%	1.1%
Basswood	4.8%	3.7%	2.1%	0.8%	0.3%	2.6%	1.5%	0.2%	1.1%	0.1%	0.6%	3.4%	3.8%	0.7%	3.2%	5.3%
Beech	***20.3%***	0.4%	0.1%	2.4%	–	14.5%	–	–	–	–	–	2.3%	4.9%	–	–	–
Hemlock	8.3%	15.7%	***22.3%***	11.8%	8.2%	***17.8%***	0.1%	0.1%	11.7%	–	0.2%	–	–	–	–	–
Red maple	0.9%	0.8%	–	0.2%	–	1.0%	–	–	–	–	–	–	–	–	–	–
Soft maple	0.9%	0.3%	–	–	–	0.5%	–	–	0.1%	–	0.7%	0.1%	–	–	–	0.2%
Sugar maple	12.7%	***16.4%***	13.8%	4.3%	4.6%	10.1%	9.2%	1.4%	7.4%	0.1%	4.0%	6.4%	8.9%	0.4%	7.1%	***18.3%***
White ash	2.0%	0.8%	0.2%	0.3%	–	0.7%	0.3%	–	0.1%	0.1%	0.2%	1.1%	1.9%	0.1%	0.5%	0.4%
Yellow birch	2.4%	15.5%	18.3%	2.7%	6.0%	4.1%	8.0%	0.7%	6.0%	–	2.0%	0.1%	0.1%	–	0.3%	3.8%
OTHER HARDWOODS																
Aspen	2.2%	2.8%	1.8%	6.3%	7.1%	3.2%	6.7%	4.4%	7.4%	1.5%	2.9%	1.8%	0.7%	1.0%	3.2%	14.8%
Birch	–	–	–	–	–	–	–	–	–	0.1%	0.5%	0.1%	–	–	0.5%	1.8%
Paper birch	1.5%	4.8%	3.6%	4.8%	9.1%	2.9%	8.0%	2.9%	8.5%	0.1%	1.4%	0.2%	0.1%	–	0.4%	1.1%
Ironwood	2.0%	1.4%	0.6%	0.1%	0.1%	0.9%	0.5%	–	0.1%	–	0.2%	1.6%	2.4%	0.1%	0.7%	2.2%
LOWLAND																
Black ash	7.1%	2.0%	1.1%	1.3%	0.2%	3.8%	2.8%	0.7%	1.5%	0.2%	0.5%	1.9%	3.2%	–	0.3%	1.4%
Cedar	4.6%	1.0%	4.4%	5.7%	2.5%	11.8%	4.2%	0.7%	6.7%	0.0%	–	0.3%	0.1%	–	–	–
Elm	6.1%	5.9%	2.4%	0.7%	0.3%	2.8%	2.9%	0.7%	1.0%	0.4%	0.9%	4.2%	4.1%	0.9%	4.0%	8.6%
Tamarack	3.7%	3.3%	8.1%	7.3%	12.7%	5.4%	14.0%	5.0%	6.5%	2.1%	8.3%	2.5%	0.6%	–	0.7%	0.3%

scapes in Province 212 were eastern white pine (*Pinus strobus*) (16%), eastern hemlock (10.7%), sugar maple (*Acer saccharum*) (8.9%), red pine (*Pinus resinosa*) (8%), tamarack (*Larix laricina*) (7.3%), yellow birch (*Betula alleghaniensis*) (7.1%), paper birch (*Betula papyrifera*) (5.1%), and jack pine (*Pinus banksiana*) (5.1%) (Table 3.9). American beech was a large component of upland forests in the eastern part of Province 212, with witness tree RIVs of 20.3% in the Central Lake Michigan Coastal Ecological Landscape and 14.5% in the Northern Lake Michigan Coastal Ecological Landscape. The southern extent of the boreal forest was found in Province 212; according to Finley, over 450,000 acres of boreal forest occurred in the Superior Coastal Plain Ecological Landscape (Finley 1976), which represented approximately half of the total area of that ecological landscape (Table 3.8).

Open Upland Habitats

Historically, Province 222 supported a variety of open and semi-open upland habitats, including prairies, savannas (including oak openings and barrens), and shrublands (Figure 3.22). Finley (1976) estimated that almost all of the presettlement vegetation in the ecological landscapes in Province 222, except for the Central Sand Plains and Central Sand Hills ecological landscapes, supported fairly large acreages of scattered prairies. Oak savannas (especially the bur oak-dominated "oak openings") were common in the Western Coulees and Ridges, Southwest Savanna, and Southeast Glacial Plains ecological landscapes (Figure 3.22). While upland brush habitats were relatively rare historically, locally they were quite common in the northern portion of the Western Coulees and Ridges Ecological Landscape as well as in the Western Prairie. Jack pine barrens and oak barrens were the only relatively open upland habitats to be found commonly in parts of Province 212, with large acreages present in the Northwest Sands and Northeast Sands ecological landscapes and to a lesser degree in the Northern Highland Ecological Landscape. Barrens communities were also quite extensive in the Central Sand Plains Ecological Landscape in Province 222.

Wetland Habitats

Both open and forested wetlands were historically common across most of the state (Figure 3.23). According to Finley's classification (Finley 1976), there were approximately 5 million acres of wetlands in the state. Due to the coarse nature

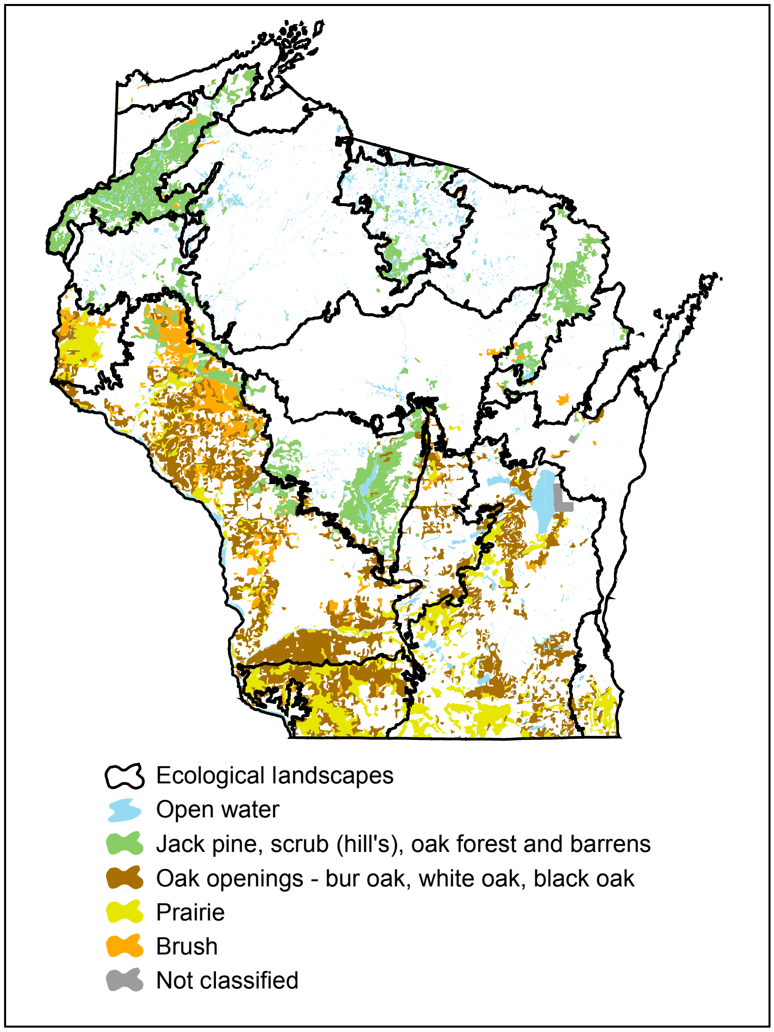


Figure 3.22. *Open and semi-open upland habitats at the time of Euro-American settlement, based on Finley's original vegetation classification.*

Coastal Plain Marsh, an unusual and fragile wetland community that can harbor rare plants disjunct from their main ranges in the eastern U.S. Photo by Thomas Meyer, Wisconsin DNR.

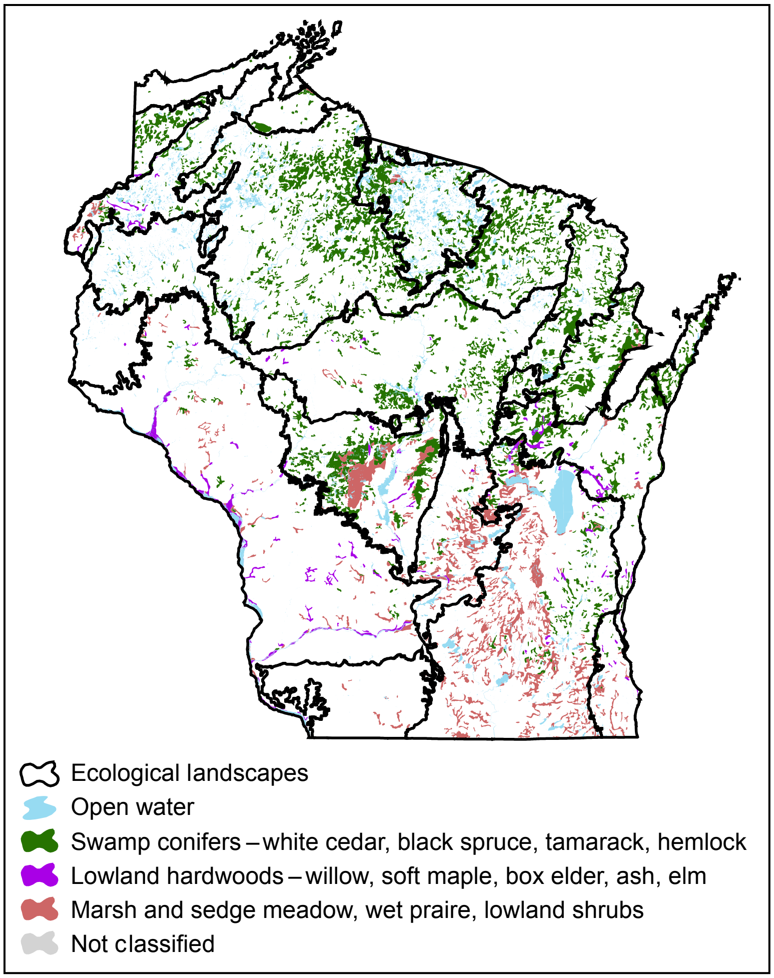


Figure 3.23. *Wetland habitat at the time of Euro-American settlement, based on Finley's original vegetation classification.*

of the PLS data, as well as current definitions of wetlands, it is commonly understood that Finley's map greatly underestimates the amount of wetlands in the state (Dahl 1990, Wisconsin DNR 1992). For a more complete discussion of wetlands and wetland changes, see the "Wetland Communities" section in Chapter 2, "Assessment of Current Conditions."

Current Vegetation

Below is a comparison of the vegetation among the ecological landscapes of the state as it occurred in the 1993 WISCLAND classification of satellite imagery (Wisconsin DNR 1993) (for information on WISCLAND, see Appendix C, "Data Sources Used in the Handbook," in Part 3 of the handbook, "Supporting Materials"). Both the number of acres of a given vegetation type within an ecological landscape and the percentage of that vegetation type within an ecological landscape are presented. The number of acres indicates the extent of a vegetation type within a given ecological landscape (see Table 3.1 in the "Physical Characteristics" section of this chapter). Because of the significant size differences between Wisconsin's ecological landscapes, the percentage of a vegetation type within an ecological landscape gives a more complete portrayal of the vegetation composition than just the raw acreage numbers. This can be an important factor when weighing management opportunities. Considerations such as ecological context and condition; site content; ownership and land use patterns; the amount of disturbance, fragmentation, and isolation; and other factors help to determine where the best opportunities for management of any given vegetation type occur.

More detailed information on Wisconsin's native vegetation and opportunities for management can be found in the seven statewide natural community sections in Chapter 2, "Assessment of Current Conditions," and in the 16 ecological landscape chapters.

Forests

■ **Upland Forest**. Today, upland forests are still extensive and form the matrix vegetation in the northern part of the state (though upland forests in other areas are, of course, also important). The North Central Forest Ecological Landscape has the most acres of upland forest of any ecological landscape in the state by a large margin (Figure 3.24). The Western Coulees and Ridges Ecological Landscape has the second highest acreage of upland forest and the most acres of upland forest of any ecological landscape south of the Tension Zone.

The Superior Coastal Plain has the most upland forest by the percentage of total area within the ecological landscape compared to any other ecological landscape (Figure 3.25). However, the Northwest Sands, North Central Forest, Northeastern Sands, Northwest Lowlands, and Northern Highland ecological landscapes have greater than 50% of their land area in upland forest (if lowland forest was included in this analysis, most of these ecological landscapes would have a greater percentage of total forest cover than the Superior Coastal Plain, which has very little lowland forest and is also one of the smaller ecological landscapes. In fact, the upland forest in the Superior Coastal Plain is significantly more fragmented than the more extensive contiguous forests in the other ecological landscapes due to dispersed agricultural development, a factor which limits certain forest management opportunities at large scales). See below under "All Forests."

The Central Sand Plains has the most upland forest by percentage of total land area of any ecological landscape south of the Tension Zone. It should be noted, however, that in many parts of the Central Sand Plains much of the upland forest is on the dry end of the spectrum. At many locations the present forests were historically pine or oak barrens. Today's forests are, in many cases, the artifacts of decades of fire suppression—they do not necessarily represent forested conditions prior to European settlement.

Forested Wetlands. The North Central Forest Ecological Landscape has more than twice as many acres of forested wetlands than any other ecological landscape in the state (Figure 3.26). The Forest Transition Ecological Landscape has the second most wetland forest acres, and the Central Sand Plains Ecological Landscape has the third most acres in wetland forest, the most of any ecological landscape south of the Tension Zone. According to the Wisconsin Wetlands Inventory (WWI) data, the North Central Forest actually has more than 800,000 acres of forested wetlands, still more than double any other ecological landscape. However, according to WWI, the Southeast Glacial Plains Ecological Landscape has approximately 240,000 acres of forested wetland, exceeding the amount of forested wetlands in the much smaller Central Sand Plains Ecological Landscape by 20,000 acres. These discrepancies between data sets are not unexpected because the methodologies used to classify land cover are different. See Appendix C, "Data Sources Used in the Handbook," in Part 3 of the handbook for further discussion of this issue. According to both WISCLAND land cover data and WWI, the Southwest Savanna Ecological Landscape has by far the lowest amount of forested wetland, totaling only about 1,000 acres.

According to WISCLAND, the Northeast Sands, Northern Lake Michigan Coastal, North Central Forest, Northern Highland, and Northwest Lowlands ecological landscapes each contain more than 10% wetland forest (Figure 3.27). According to WWI, the Northwest Lowlands has the highest percentage of forested wetland cover of any ecological landscape, at over 18%.

All Forests. Combining upland and wetland forest types gives a clearer picture of the total amount of forest cover in different ecological landscapes of the state and has a direct bearing on many forest management opportunities. According to WISCLAND land cover data (Figure 3.28), the North Central Forest Ecological Landscape has the most forested area in total by far. The Western Coulees and Ridges Ecological Landscape has the second most forest, followed by the Forest Transition Ecological Landscape.

The percentage of all forests (upland and wetland forests combined) shows the total amount of forest in each ecological landscape.

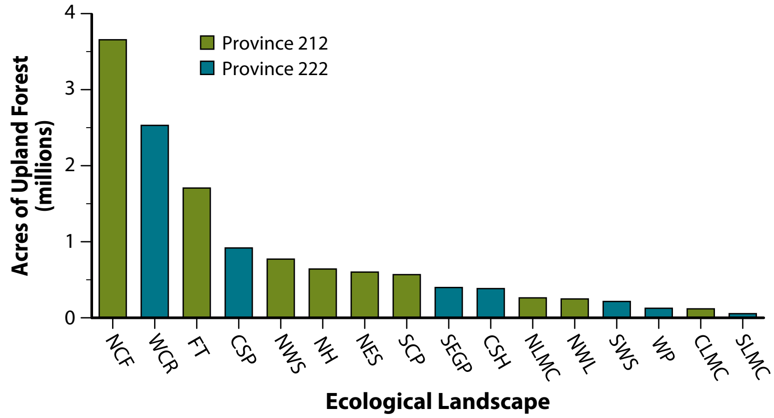


Figure 3.24. *Comparison of the acres of upland forest within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

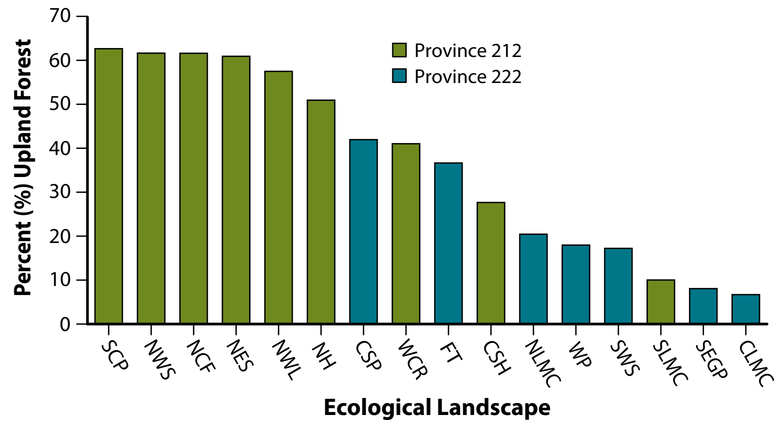


Figure 3.25. *Comparison of percentage of upland forest acres within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

Extensive upland deciduous forests in the North Central Forest Ecological Landscape. Conifers are now absent from many areas or are limited to the wetlands. Photo by Eunice Padley, Wisconsin DNR.

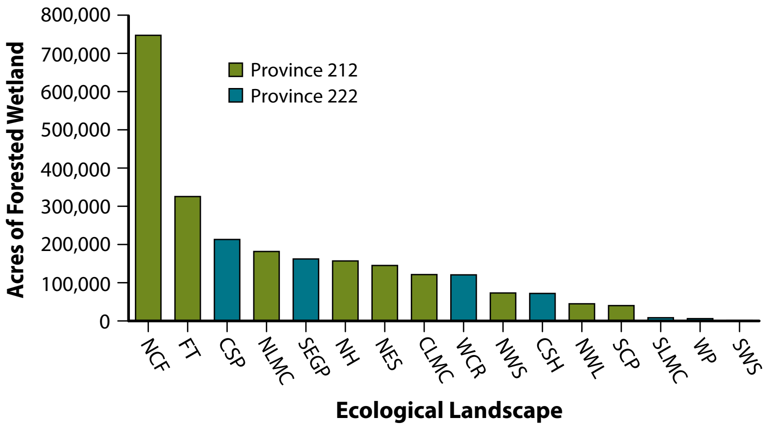


Figure 3.26. *Comparison of the acres of wetland forest within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

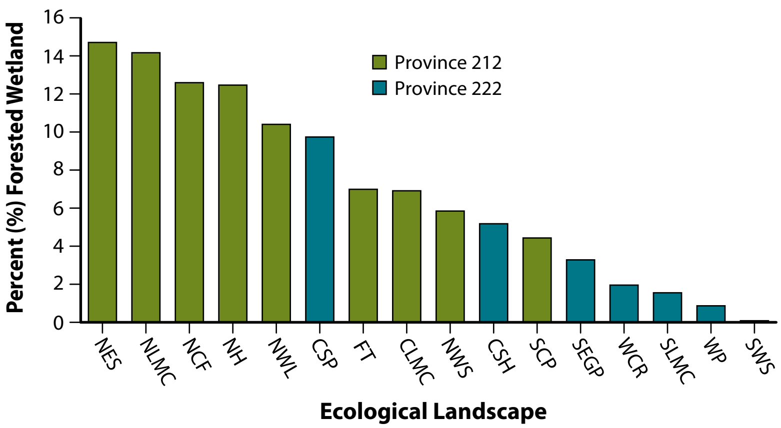


Figure 3.27. *Comparison of percentage of wetland forest acres within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

According to WISCLAND, the Northeast Sands and North Central Forest ecological landscapes are over 70% forested (Figure 3.29). The Northwest Lowlands, Northwest Sands, Superior Coastal Plain, and Northern Highland ecological landscapes are over 60% forested. The Central Sand Plains has the highest percentage of forest cover of all ecological landscapes south of the Tension Zone. Five ecological landscapes are less than 20% forested; all of these are south of the Tension Zone (Western Prairie, Southwest Savanna, Central Lake Michigan Coastal, Southern Lake Michigan Coastal, and Southeast Glacial Plains).

Many changes have taken place in Wisconsin forests over time. One major change was the loss of conifers in our upland northern forests. For example, eastern hemlock and eastern white pine were the most widespread and abundant or prominent conifer species in the northern forest. They declined dramatically or even disappeared from many areas of northern Wisconsin following the Cutover (see "Northern Forest Communities" in Chapter 2, "Assessment of Current Conditions"). Additional changes to forests include the loss of large forest patches; the loss of old-growth forests; the increase in fragmentation and homogenization of forests; the increase in deer populations, which in some places are having negative impacts on forest composition, structure, and function in some places; negative effects of exotic earthworms on soils and understory plants; and the spread of invasive plants (see "Northern Forest Communities" and "Southern Forest Communities" in Chapter 2, "Assessment of Current Conditions").

Another change in vegetation cover that has taken place since Euro-American settlement has been the extensive planting of red pine monocultures. This has occurred in formerly forested areas and on many previously nonforested lands, such as those that supported pine barrens, oak barrens, and sand prairies, especially in regions with sandy soils. Red pine has been planted to increase yields of forest crops and to convert nonforested lands into forest crop production. According to Forest Inventory and Analysis data from 2007, red pine plantations occur in all ecological landscapes, covering a total of nearly 550,000 acres (Table 3.10). The largest number of acres planted to red pine has been in the Central Sand Plains (95,000 acres), Northwest Sands (86,000 acres), and North Central Forest (70,000 acres) ecological landscapes (Table 3.10). Over 40,000 acres have been planted in each of the following

Pine monocultures have replaced natural communities in many areas. Many, such as the red pine plantation seen here, have a very simplified structure and offer little habitat to plants and wildlife. Photo by Jeff Martin.

ecological landscapes: Forest Transition, Central Sand Hills, Northeast Sands, and Western Coulees and Ridges. Generally, red pine plantations are managed primarily to produce timber. Although there may be economic advantages to plantations, they are generally poor wildlife habitat and seldom, if ever, support a diverse community of native plants (Kohn 1974). This is especially true when the previous vegetation had been barrens or prairie, which includes many light-demanding plant species that will not thrive under plantation conditions as shading increases. Of particular concern is replacing the globally rare Pine Barrens and Oak Barrens communities as well as the regionally declining natural jack pine forests with red pine plantations in the Northwest Sands, Northeast Sands, and Central Sand Plains ecological landscapes.

Red pine occurs naturally in the northern two-thirds of the state (Figure 3.30); however, natural red pine stands are relatively rare at this time (Figure 3.31). Only about 143,000 acres of naturally occurring red pine was projected from Forest Inventory Analysis data for the state (Table 3.10). Most naturally occurring red pine is found in the Northwest Sands (35,000 acres), Northern Highland (30,000 acres), and North Central Forest (18,000 acres) ecological landscapes. Today, the vast majority of forested land classified as red pine in the state is in plantations. In any given ecological landscape, the percentage of red pine plantations ranges from 50% to 100% of all red pine forests.

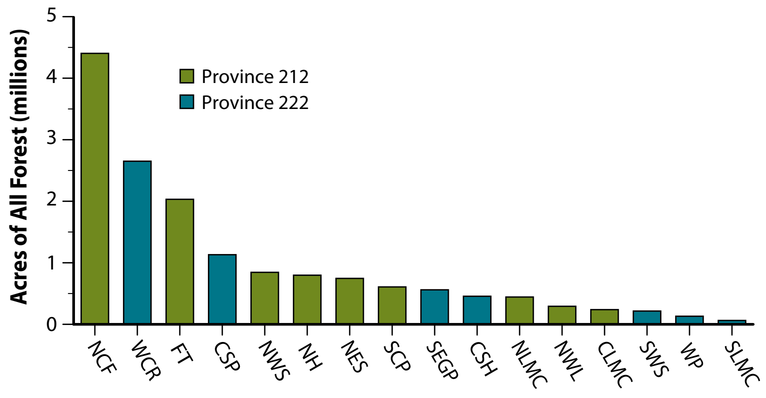


Figure 3.28. *Comparison of the acres of all forest within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

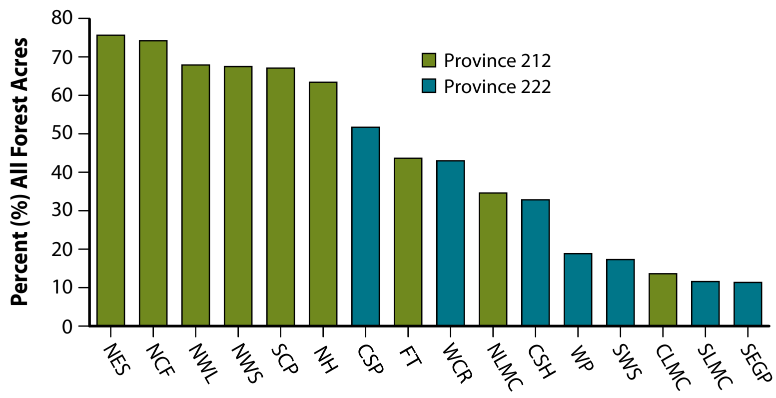


Figure 3.29. *Comparison of the percentage of all forest acres within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

Table 3.10. *Acres of "timberland" classified as naturally occurring red pine and red pine plantations along with the sampling error (acreages with over 25% sampling error are highlighted in red) by ecological landscape.*

	Acreage of timberland			Sampling error		
Ecological landscape	**Natural**	**Plantation**	**Total**	**Natural**	**Plantation**	**Total**
Central Lake Michigan Coastal	–	212	212	–	157%	157%
Central Sand Hills	5,668	60,773	66,440	30%	9%	9%
Central Sand Plains	12,310	94,612	106,923	21%	7%	7%
Forest Transition	10,314	67,536	77,850	22%	9%	8%
North Central Forest	17,936	70,339	88,275	17%	9%	8%
Northeast Sands	12,735	47,414	60,149	20%	10%	9%
Northern Highland	30,219	37,835	68,053	13%	12%	9%
Northern Lake Michigan Coastal	2,540	13,770	16,311	45%	19%	18%
Northwest Lowlands	3,175	3,175	6,349	40%	40%	29%
Northwest Sands	34,854	85,982	120,836	12%	8%	7%
Southeast Glacial Plains	967	7,717	8,685	73%	26%	24%
Southern Lake Michigan Coastal[a]	–	–	–	–	–	–
Southwest Savanna[a]	–	–	–	–	–	–
Superior Coastal Plain	4,200	6,332	10,533	35%	29%	22%
Western Coulees and Ridges	7,413	40,782	48,195	26%	11%	10%
Western Prairie	564	11,520	12,084	96%	21%	21%
State total	**142,895**	**548,000**	**690,894**	**6%**	**3%**	**3%**

Source: Data from 2007 Forest Inventory and Analysis (USFS 2010).
[a]There are no Forest Inventory and Analysis plots classified as red pine in the Southern Lake Michigan Coastal or Southwest Savanna ecological landscapes.

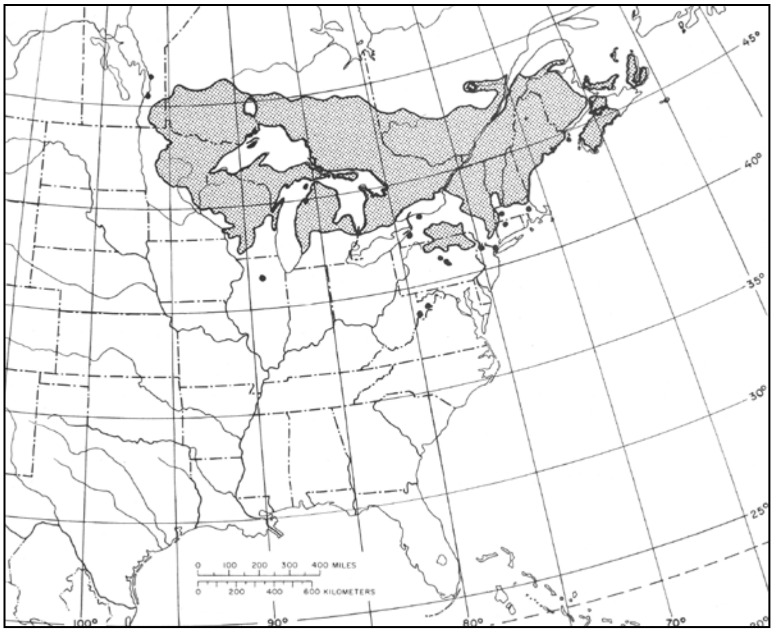


Figure 3.30. *Natural range of red pine (Burns and Honkala 1990).*

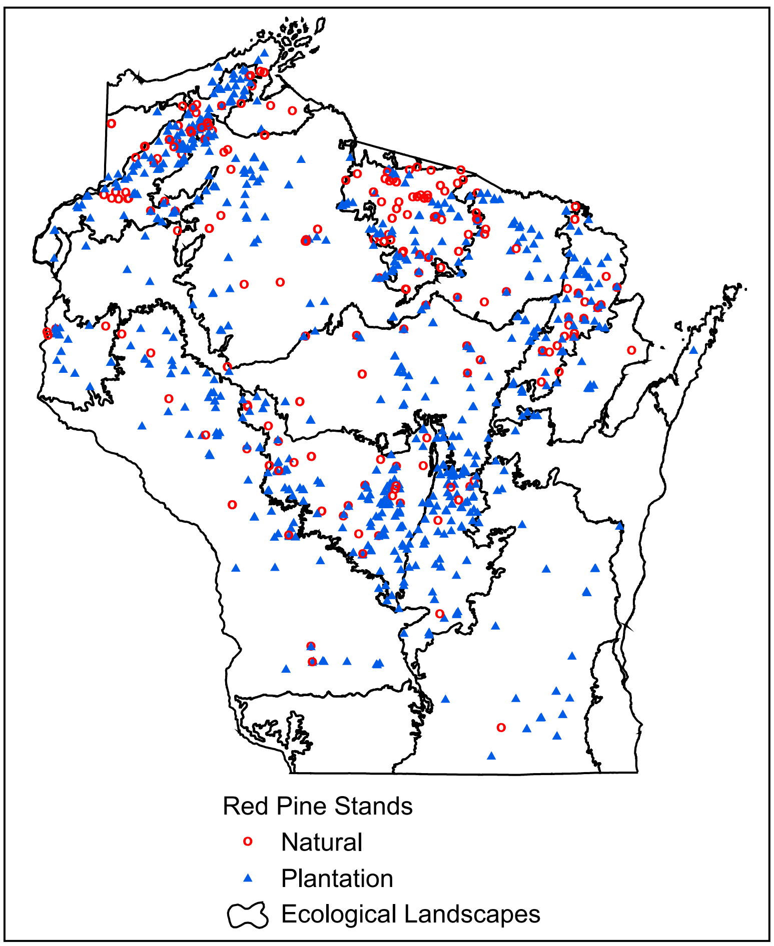


Figure 3.31. *Locations of plantations and natural stands of red pine in the ecological landscapes of Wisconsin. Data from 2007 Forestry Inventory and Analysis (USFS 2010).*

Wetlands

Wisconsin's wetland communities include herbaceous wetlands (marsh, sedge meadow, low prairie, fen, and open bog), wetland shrub communities (shrub swamp), and forested wetlands (including conifer swamps and lowland hardwood forests). (See the "Forested Wetlands" section in "Current Vegetation," above, for a description of that community group.) For additional details on each of the specific wetland communities, see Appendix G, "Descriptions of Natural Communities, Aquatic Features, and Selected Habitats," in Part 3 of the handbook.

■ **Herbaceous Wetlands.** Based on the Wisconsin Wetlands Inventory (WWI), the largest number of acres of herbaceous wetlands (basically, marshes and sedge meadows, including the WWI classes of aquatic bed and emergent/wet meadow) occurs in the Southeast Glacial Plains Ecological Landscape (over 340,000 acres of herbaceous wetlands) (Table 3.11). For example, Horicon Marsh, a 32,000-acre cattail-dominated emergent marsh in southeastern Wisconsin, is the largest wetland of its type in the United States (USFWS 2011).

The Forest Transition, Central Sand Plains, and Western Coulees and Ridges ecological landscapes all have more than 100,000 acres of herbaceous wetlands. Combined, these four ecological landscapes contain nearly 70% of the total area of herbaceous wetlands in the state. The Southeast Glacial Plains Ecological Landscape is characterized by glacial features such as ground moraines that are favorable for wetland development. A large part of the Central Sand Plains Ecological Landscape encompasses the sandy bed of former Glacial Lake Wisconsin. Though sand is generally conducive to good drainage, here the lakebed sands are underlain by fine sediments, and as a consequence, in many areas the water table is very high and wetlands are abundant. The Forest Transition Ecological Landscape features a variety of glacial landforms, including moraines and outwash, often modified by postglacial processes. Wetlands now occupy morainal depressions and former drainage channels. Most of the Western Coulees and Ridges Ecological Landscape was not glaciated, and wetlands there are associated almost entirely with the broad floodplains of the Mississippi, Wisconsin, Chippewa, and Black rivers.

The ecological landscapes with the largest percentage of total area covered by herbaceous wetlands is the Southeast Glacial Plains (6.7%), followed by the Central Sand Hills (5.9%) and Central Sand Plains (5.3%). No other ecological landscape has more than 5% of its total area covered by herbaceous wetlands.

Wetland Shrubs. According to the WWI data, the North Central Forest (nearly 430,000 acres), Forest Transition (approximately 155,000 acres), Central Sand Plains (approximately 144,000 acres), and Southeast Glacial Plains (approximately 126,000 acres) ecological landscapes have the largest number of acres of wetland shrubs (Table 3.11). Combined, these four ecological landscapes contain nearly two-thirds of the shrub wetlands in the state. Most shrub wetlands in the northern part of the state are Alder Thicket. In the southern part of the state, most shrub wetlands are of the Shrub-carr type. (See the descriptions of natural communities in Appendix G, "Descriptions of Natural Communities, Aquatic Features, and Selected Habitats," in Part 3 of the handbook, "Supporting Materials.") However, both wetland shrub types occur in central Wisconsin and intermix, to some degree, in both northern and southern Wisconsin.

The highest percentage of wetland shrubs within an ecological landscape is in the Northwest Lowlands Ecological Landscape (10.5% of the area), followed by the Northern Central Forest (7.2%), Central Sand Plains (6.6%), Northern Highland (6.3%), and Northwest Sands (5.7%) ecological landscapes. No other ecological landscape has more than 5% cover of wetland shrubs.

For more information on the Wisconsin Wetlands Inventory, see Appendix C, "Data Sources used in the Handbook."

Shrub-carr along the Milwaukee River within the Kettle Moraine State Forest, Fond du lac County. Photo by Eric Epstein, Wisconsin DNR.

Table 3.11. *Acres of wetlands in the ecological landscapes of Wisconsin.*

Ecological landscape	Aquatic bed	Emergent/ wet meadow	Filled/ drained meadow	Flats/ unvegetated wet soil	Forested	Moss	Scrub/shrub	Wet	Total
Central Lake Michigan Coastal	88	38,572	1,069	128	173,686	–	34,650	–	248,193
Central Sand Hills	3,674	81,569	4,099	429	107,551	–	56,803	–	254,126
Central Sand Plains	188	115,877	2,188	328	261,391	69	143,895	23,427	547,363
Forest Transition	4,338	116,834	688	1,248	395,164	–	155,289	41,453	715,015
North Central Forest	5,285	64,285	113	40	874,125	–	428,946	35,426	1,408,219
Northeast Sands	156	9,461	94	15	157,421	–	30,689	–	197,836
Northern Highland	882	7,675	164	–	150,741	–	79,380	–	238,842
Northern Lake Michigan Coastal	74	15,880	236	18	210,582	–	30,511	–	257,301
Northwest Lowlands	108	6,390	26	12	76,529	–	45,315	–	128,380
Northwest Sands	2,871	31,346	50	12	85,951	–	71,155	51	191,436
Southeast Glacial Plains	10,882	330,284		–	246,414	–	125,981	–	713,561
Southern Lake Michigan Coastal	787	15,507	379	2,508	18,604	–	7,995	–	45,780
Southwest Savanna	90	6,597	612	–	1,015	–	488	–	8,802
Superior Coastal Plain	25	4,404	490	19	68,439	–	37,437	–	110,813
Western Coulees and Ridges	7,892	100,642	1,132	1,773	142,993	–	37,059	–	291,491
Western Prairie	398	9,622	17	21	11,806	–	3,507	–	25,371
State total	**37,737**	**954,944**	**11,358**	**6,551**	**2,982,412**	**69**	**1,289,100**	**100,357**	**5,382,529**

Source: Data from the Wisconsin Wetland Inventory (Wisconsin DNR 2010b).

Other Upland Habitats

Upland Shrubs. Most upland shrub habitat in Wisconsin consists of recent cutovers, herbaceous vegetation succeeding to shrub dominance (a temporary stage in the absence of further intervention), some frost pockets, and intensively managed barrens where the trees are kept at reduced stature and density by the use of frequent prescribed fire and mechanical cutting. According to 1993 WISCLAND land cover data, the Northwest Sands, North Central Forest, and Northern Highland ecological landscapes have the largest number of acres of upland shrubs (Figure 3.32). The highest percentage of upland shrubs within an ecological landscape reported by WISCLAND is the Northwest Sands (8.2% of the area) (Figure 3.33), followed by the Northern Highland (3.3%) and Superior Coastal Plain ecological landscapes (2.5%).

Grasslands

The acreage of native grasslands (excepting a few wetland types), especially prairie, is so negligible that it does not show up in WISCLAND data at all. According to WISCLAND's classification, "grassland" encompasses CRP lands with nonwoody cover, pasture, old field, idle land with nonwoody cover, and "grass" (including timothy and other grass-based hay, and small grains such as oats, rye, wheat, and barley). The Western Coulees and Ridges, Forest Transition, and Southeast Glacial Plains ecological landscapes have the largest number of acres typed as grassland (Figure 3.34). In the Western Coulees and Ridges, the broader ridge tops and valley bottoms often support agriculture; the steep side slopes remain in forest cover. Bluff or "goat" prairies are still found on some steep south- or west-facing slopes. Soils on ridge tops in the Western Coulees and Ridges Ecological Landscape are sometimes thin, and such areas may be better suited to supporting grasslands (and some level of grazing) than row crops. Some land is highly erodible, and since 1985, highly erodible land could be enrolled in the Conservation Reserve Program, which requires agricultural fields to be in grass or tree cover.

The Western Prairie, Central Sand Hills, Superior Coastal Plain, and Southern Lake Michigan Coastal ecological landscapes have

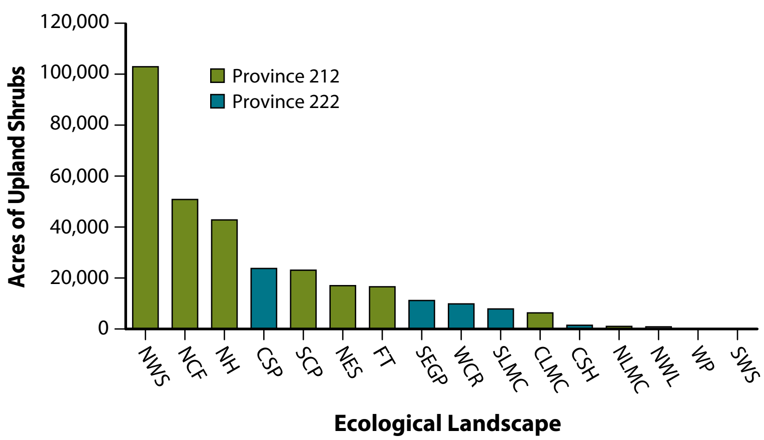


Figure 3.32. *Comparison of the acres of upland shrubs within each ecological landscape of Wisconsin. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

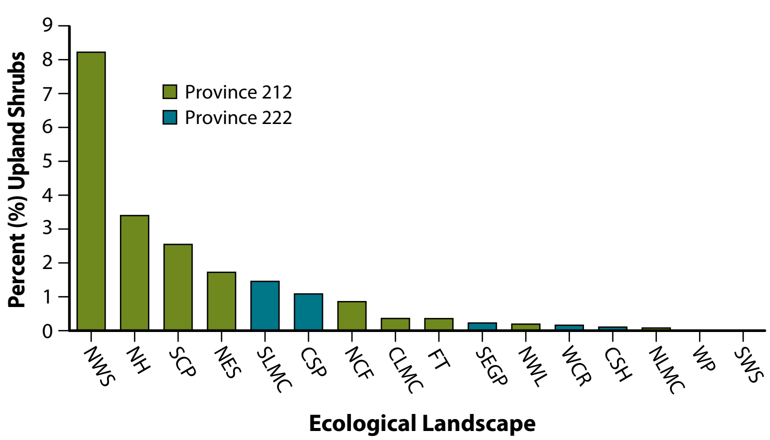


Figure 3.33. *Comparison of the percentage of upland shrub within each ecological landscape of Wisconsin. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

Avoca Prairie and Savanna State Natural Area is located in the Lower Wisconsin River Valley. It features the largest natural tallgrass prairie east of the Mississippi River and is actively managed to maintain its open condition and control invasives. Photo by Thomas Meyer, Wisconsin DNR.

more than 15% of their area in grassland (Figure 3.35). The Forest Transition, Western Coulees and Ridges, Central Sand Plains, Southeastern Glacial Plains, and Southwest Savanna ecological landscapes have 10%–15% of their area in grassland. The rest of the ecological landscapes have less than 10% of their area in grassland. Large blocks of contiguous grassland are now scarce.

Open Water

The Southeast Glacial Plains, North Central Forest, and Northern Highland ecological landscapes have the largest number of acres of open water (Figure 3.36) due to the glacial features that occur there (e.g., ground moraines and pitted outwash plains). The highest percentage of open water is in the Northern Highland Ecological Landscape (12.1% of its area) with its concentration of glacial lakes, followed by the Southeast Glacial Plains (5.7%) and Northwest Sands ecological landscapes (4.8%) (Figure 3.37).

Aurora Lake, a 94-acre undeveloped, soft water drainage lake in Vilas County. Photo by Thomas Meyer, Wisconsin DNR.

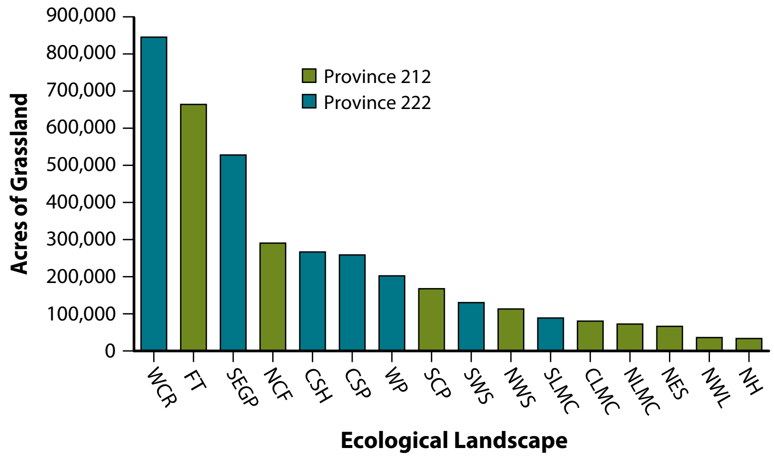


Figure 3.34. *Comparison of the acres of grassland within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

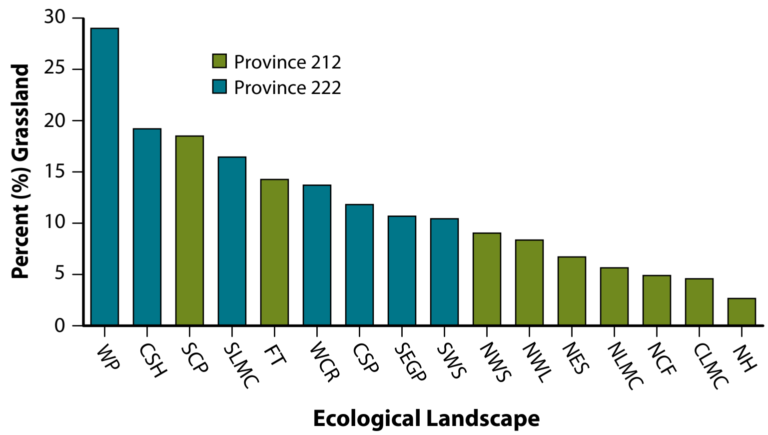


Figure 3.35. *Comparison of the percentage of grassland within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

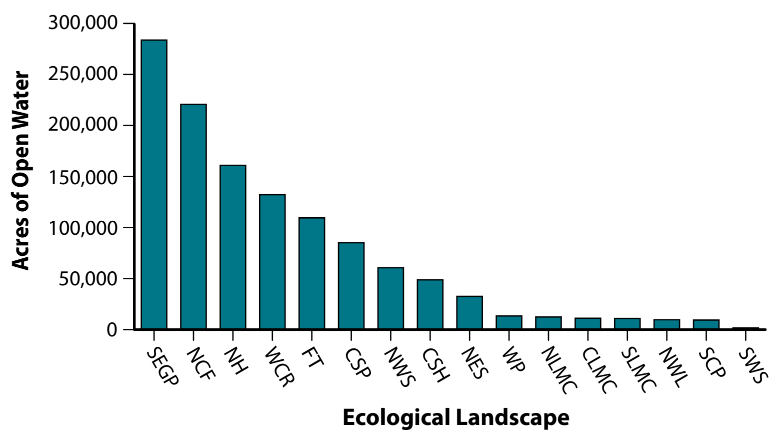


Figure 3.36. *Comparison of the acres of open water within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

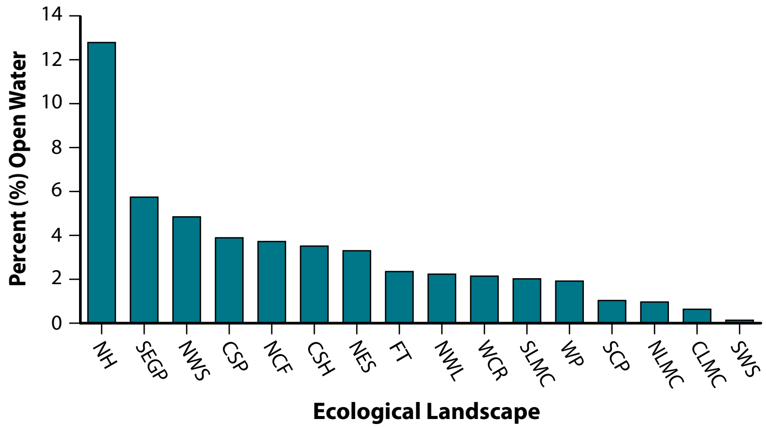


Figure 3.37. *Comparison of the percentage of open water within each ecological landscape. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

Cornfield. Photo by Wisconsin DNR staff.

Natural Communities

For a comparison of which natural communities occur in which ecological landscape, see Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3 of the handbook ("Supporting Materials"). More detailed descriptions of the natural communities that occur in each ecological landscape can be found in the "Natural Communities" section in the individual ecological landscape chapters and in Appendix G, "Descriptions of Natural Communities, Aquatic Features, and Selected Habitats."

Current Land Use

Agriculture

The majority of agriculture occurs in the southern two-thirds of the state where the climate, length of growing season, and soils are more favorable for agriculture than in the northern third of the state. Based on WISCLAND land cover data, the Southeast Glacial Plains and Western Coulees and Ridges ecological landscapes have the largest number of agricultural acres, with over 2 million acres each (Figure 3.38). The Forest Transition and Central Lake Michigan Coastal ecological landscapes have over a million acres of agriculture each, yet both lie north of the Tension Zone. However, the Forest Transition and Central Lake Michigan Coastal ecological landscapes both border and partially straddle the Tension Zone. In addition, the climate of the Central Lake Michigan Coastal Ecological Landscape is moderated by Lake Michigan, making it more favorable for agriculture than ecological landscapes farther north and west.

The Southwest Savanna and Central Lake Michigan Coastal ecological landscapes have almost 70% of their area in agricultural usage (Figure 3.39). The Southeast Glacial Plains and Northern Lake Michigan Coastal ecological landscapes have more than 50% of their area in agriculture. The Northwest Lowlands, Northwest Sands, Northern Highland, and Superior Coastal Plain ecological landscapes rank as having the lowest area and percentage of land in agricultural usage.

Landscape dominated by agriculture in southern Wisconsin. Photo by Wisconsin DNR staff.

Cutting hay. Photo by Wisconsin DNR staff.

Female Bobolink (Dolichonyx oryzivorus) *with food. Bobolinks and other bird species nest in working hay fields in Wisconsin. Nesting attempts can be successful, but only if mowing is delayed until after July 15th to allow the young a chance to fledge. Photo by Jack Bartholmai.*

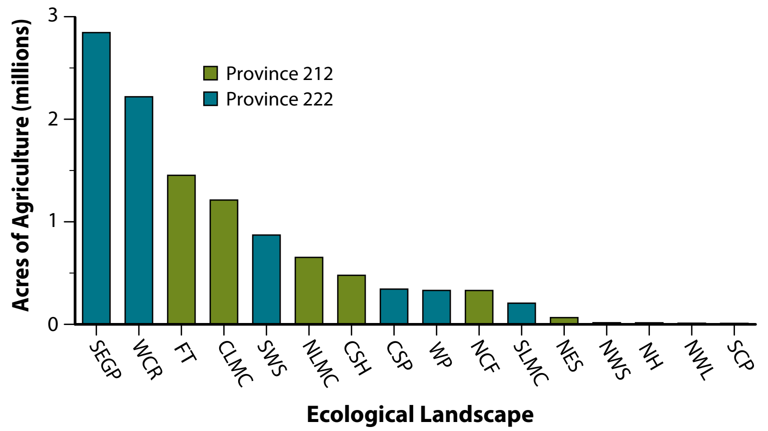


Figure 3.38. *Comparison of the acres of agriculture within each ecological landscape of Wisconsin. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

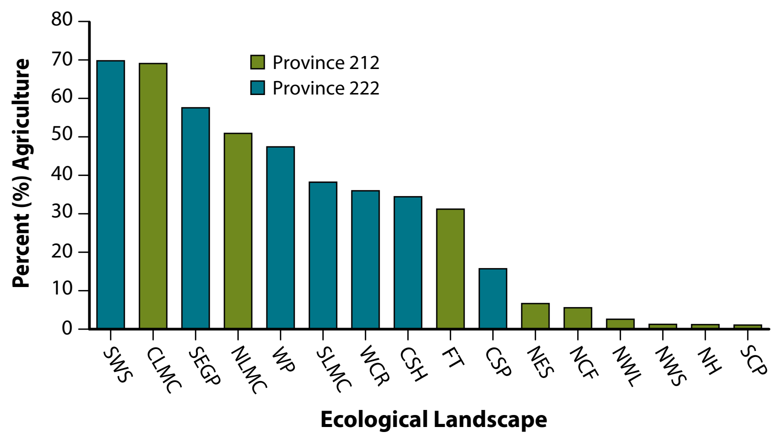


Figure 3.39. *Comparison of the percentage of agriculture within each ecological landscape of Wisconsin. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

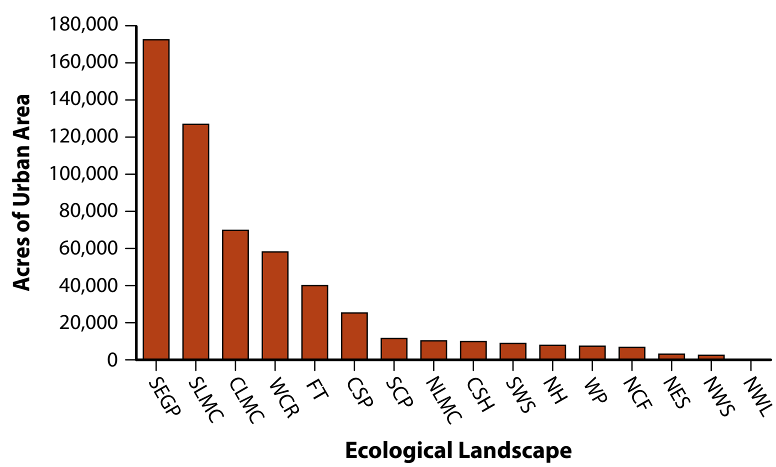


Figure 3.40. *Comparison of the acres of urban areas within each ecological landscape of Wisconsin. Data from WISCLAND (Wisconsin DNR 1993). (See Table 3.1 for key to abbreviations.)*

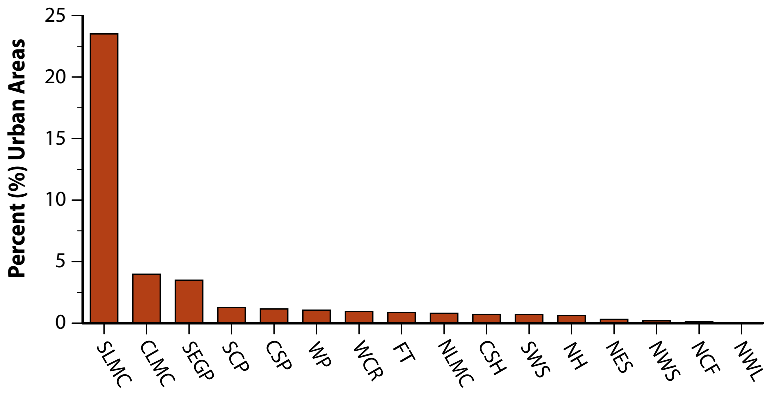


Figure 3.41. *Comparison of the percentage of urban areas within each ecological landscape of Wisconsin. Data from WISCLAND (Wisconsin DNR 1993).(See Table 3.1 for key to abbreviations.)*

Urban bike trail along Mississippi River, La Crosse. Photo by Wisconsin DNR staff.

Urban Areas

Southeastern Wisconsin is the most highly populated and developed part of the state. The most acres of urban land are in the Southeast Glacial Plains and Southern Lake Michigan Coastal ecological landscapes, which include the Milwaukee metropolitan area, Racine, Kenosha, Madison, and numerous smaller cities (Figure 3.40). The Central Lake Michigan Coastal Ecological Landscape (69,748 acres) has the third most urban acres and contains the city of Green Bay and most of the Fox River Valley cities. The Southern Lake Michigan Coastal Ecological Landscape has by far the highest percentage (23.5%) of land in urban areas (Figure 3.41). This area continues to develop rapidly.

The National Land Cover Database class of “Developed Area” (MRLC 2011) uses a slightly different classification scheme than WISCLAND’s “Urban” class but shows a similar order of the development and urbanization of ecological landscapes by total acres (Figure 3.42) and percentage of total area (Figure 3.43).

The amount of impervious surfaces within an ecological landscape reflects the pattern of developed land. Impervious surfaces can have large negative effects on the ecology of an area, especially water quality (see the “Aquatic Features” section of this chapter). Based on National Land Cover Data (MRLC 2011), the percentage of impervious surfaces is four times higher in the Southern Lake Michigan Coastal Ecological Landscape (16.5%) than in any other ecological landscape (Figure 3.44). The Central Lake Michigan Coastal (3.8%) and Southeast Glacial Plains (2.9%) ecological landscapes have the second and third highest percentage of impervious surfaces of the ecological landscapes in the state.

Urban areas typically contain high levels of impervious surfaces, as exhibited by this Dane County mall and its surroundings. Photo courtesy of National Agriculture Imagery Program, 2008 aerial photo.

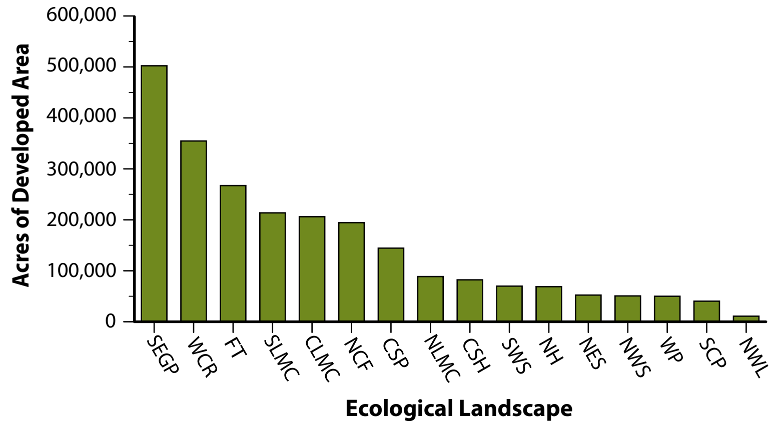


Figure 3.42. *Comparison of the total acres of developed area within each ecological landscape of Wisconsin. "Developed area" includes the NLCD classifications of "Developed, Open Space," "Developed, High Intensity," "Developed, Medium Intensity," and "Developed, Low Intensity." Data from National Land Cover Database (MRLC 2011). (See Table 3.1 for key to abbreviations.)*

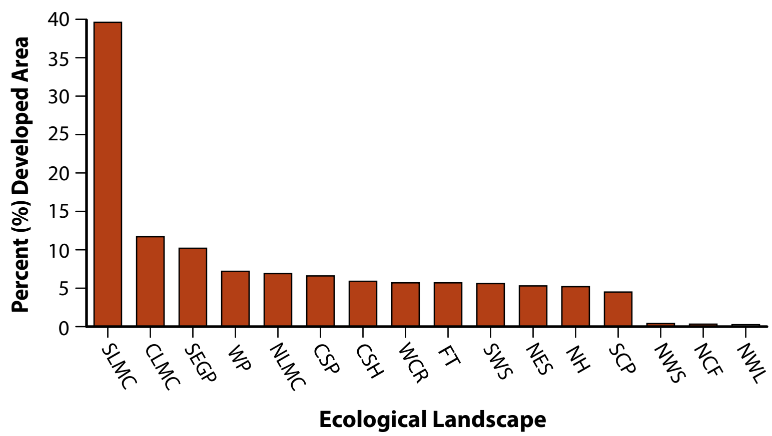


Figure 3.43. *Comparison of the percentage of developed area within each ecological landscape of Wisconsin. "Developed area" includes the NLCD classifications of "Developed, Open Space," "Developed, High Intensity," "Developed, Medium Intensity," and "Developed, Low Intensity." Data from National Land Cover Database (MRLC 2011) (See Table 3.1 for key to abbreviations.)*

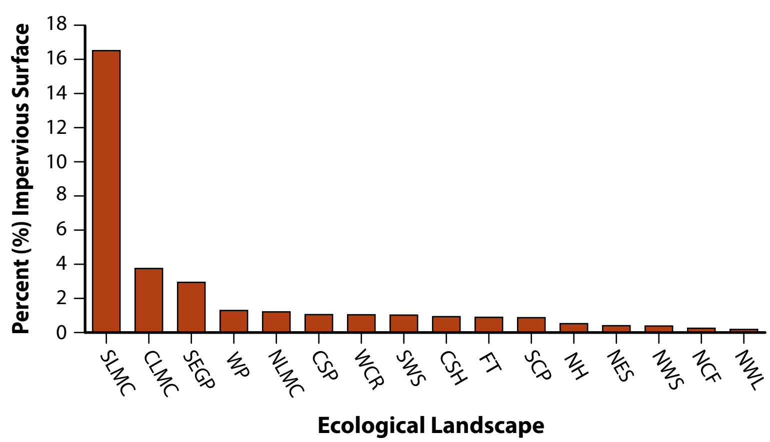


Figure 3.44. *Comparison of the percentage of impervious surfaces within each ecological landscape of Wisconsin. Data from National Land Cover Database (MRLC 2011) (See Table 3.1 for key to abbreviations.)*

Rare Species, Species of Greatest Conservation Need, and Responsibility Species

Species referred to as "rare" in this document are those that occur on the Wisconsin DNR's Natural Heritage Working List (Wisconsin DNR 2009d). This includes all species formally recognized as endangered or threatened by the State of Wisconsin and/or the federal government as well as species listed as "Special Concern" by the State of Wisconsin.

The Natural Heritage Inventory (NHI) program, housed within the Wisconsin DNR's Bureau of Endangered Resources, tracks "***elements of biodiversity***" in Wisconsin, including natural communities and rare species (Wisconsin DNR 2009d). Other elements that are tracked include aquatic features (lakes and streams) and miscellaneous features of potentially high conservation significance such as migratory bird concentration areas, surrogate grasslands (composed mostly of nonnative species), bird rookeries, bat and herptile ***hibernacula***, and caves. These miscellaneous features are not discussed directly in this section. Refer to the individual ecological landscape chapters for additional information.

The Wisconsin Natural Heritage Working List includes global and state ranks to indicate species' levels of rarity and endangerment as well as the federal and state legal status for each species. The 2009 Working List included 584 animals and 355 vascular plants. ***Bryophytes*** and lichens added another 79 and 47 species, respectively. The Working List is dynamic and is updated as new information becomes available regarding the status of rare species and natural communities. Please refer to the Wisconsin Natural Heritage Working List web page for the most recent Working List (Wisconsin DNR 2009d).

The conservation of rare species is an important aspect of ecosystem management and central to the concept of "saving all of the pieces." Each species has a role to play in maintaining functional ecosystems, not just those that are common, widespread, or desired by certain interest groups. As habitats are reduced, fragmented, and simplified and pressures on natural resources increase, rare species are at risk of being lost from an area and potentially extirpated from the state or even becoming extinct. The recovery and restoration of a species, once it becomes rare or has been lost, can be extremely difficult and expensive, so for many reasons it is in our interests to keep species from disappearing before this becomes necessary.

Understanding Rare Species

Understanding the reasons for a species' rarity is critical in order to stabilize its numbers and ensure its future viability. Some of the common reasons for rarity include loss of habitat, impaired habitat function, persecution, exploitation, extreme specialization to a narrow range of habitat conditions, genetic problems, disease, or parasitism.

When rare species are documented in an ecological landscape, it may indicate that special habitats are present there, and those habitats are likely neither common nor widespread. It can also be a signal that changes to the environment brought about over the past several centuries have had negative consequences for many species and that it is in our interest to understand what they are, why that has happened, and whether or not they can be modified or reversed.

The following are examples of important questions for understanding rare species in Wisconsin:

- Does Wisconsin have a significant part of the global population?
- Is Wisconsin at the core of the species range, on the periphery, or disjunct from it?
- Are populations of the species in question secure in other parts of its range?
- Does the species occur in a limited number of ecological landscapes, or is it more broadly distributed?
- Is the species a habitat specialist? If so, how common are those habitats and how are they distributed? What are the opportunities and trade-offs associated with restoring its habitat?
- Have potential habitats in Wisconsin and elsewhere been adequately surveyed for the species?
- Is the species distribution highly localized within an ecological landscape?
- How many populations are viable? What are their short and long-term threats?
- Are the life history characteristics for a species well understood? What would it take to better understand their needs?
- Are patch sizes and connectivity adequate to support the species? If not, what is the restoration potential?
- Is the taxonomy of the species well understood? What would be necessary to resolve taxonomic difficulties?

Distribution of Rare Species among Ecological Landscapes — What Do the Numbers Mean?

Table 3.12 provides estimates of the number of rare species documented in each of the state's 16 ecological landscapes in 2009 for purposes of general comparisons. While the distribution of rare species is of great interest to researchers, conservation planners, development project reviewers, and land and water managers, rare species counts by ecological landscape should not be the sole information source for selecting and prioritizing conservation projects. Simple comparisons among landscapes are tempting but can be misleading and may not be informative or meaningful without additional information since numerous factors influence these figures. It is important to remember that while it is the most comprehensive source of statewide information for rare species in Wisconsin with more than 20,000 records, the NHI database is by no means a complete source of rare species locations for the entire state.

The number and type of rare species present in a given ecological landscape is the result of many factors. For example, there is a wide range of sizes among the ecological landscapes. Geographic location is also important. The margins of the state contain ecological landscapes that are sometimes part of larger ecoregions in adjoining states. These areas often support species at the edges of their ranges. In addition, the shorelines of the Great Lakes and the St. Croix–Mississippi River corridor receive heavy use by migratory birds and many other organisms.

Other important factors in the number of rare species present in a landscape include land uses, types and conditions of habitats present, degree of fragmentation and habitat connectivity, invasive species impacts, geology, landforms, soils, and other factors.

The Western Coulees and Ridges is Wisconsin's largest ecological landscape. More rare plants and animals have been documented there than in any other ecological landscape. In addition to its size, a number of other factors are also important for this portion of the state (which was mostly unglaciated and is consequently often referred to as a part of the "Driftless Area"). The relatively rough topography has somewhat limited the intensive land uses that are dominant elsewhere in southern Wisconsin. The diversity of natural communities and habitats is also very high and includes many types that are rare, several that occur in no other ecological landscape (e.g., Algific Talus Slopes), and areas of certain habitats that are large compared with remnants in other ecological landscapes—especially in southern Wisconsin. Large rivers of the Western Coulees and Ridges Ecological Landscape support Wisconsin's most diverse aquatic animal assemblages, and these include many rare species.

The Northwest Lowlands is Wisconsin's smallest ecological landscape and supports a small number of rare species (15th out of the 16 ecological landscapes in the number of rare species it supports). However, this landscape has a number of abundant, viable, and species-rich habitats. For example, it contains a stretch of the highly significant St. Croix River system and some of the state's largest and least disturbed peatland complexes. Looking beyond Wisconsin's borders, the Northwest Lowlands is a small part of a much larger ecoregion that occurs mostly within the boundaries of Minnesota.

The Northern Lake Michigan Coastal Ecological Landscape is of moderate size but has a high number of rare species, due in part to its many unusual habitats. This is especially true for plants and specialized animals that inhabit the unique environments found on the Door Peninsula and the vast wetlands along the west shore of Green Bay or for organisms that are dependent in one way or another on the waters of Green Bay and Lake Michigan.

The 16 ecological landscape chapters in this handbook offer good sources of information to establish the importance of individual ecological landscapes for certain rare species and to enable us to set ecosystem management priorities. The goal is to inform decision making by coupling this information with local knowledge.

Species of Greatest Conservation Need

The Wisconsin Wildlife Action Plan (WWAP) identified Wisconsin's Species of Greatest Conservation Need (SGCN)

Table 3.12. *Number of rare species within each of Wisconsin's ecological landscapes. Note that most rare plant and animal species occur in more than one ecological landscape, so a sum of all of the ecological landscapes would greatly exceed the number of rare species in the state.*

Ecological landscape	Vertebrates	Invertebrates	Total animals	Total plants	Total rare species
Central Lake Michigan Coastal	55	76	131	45	176
Central Sand Hills	65	50	115	61	176
Central Sand Plains	57	59	116	55	171
Forest Transition	51	44	95	55	150
North Central Forest	51	60	111	95	206
Northeast Sands	20	40	60	51	111
Northern Highland	42	22	64	35	99
Northern Lake Michigan Coastal	50	56	106	102	208
Northwest Lowlands	27	37	64	24	88
Northwest Sands	45	44	89	46	135
Southeast Glacial Plains	78	77	155	109	264
Southern Lake Michigan Coastal	32	14	45	49	94
Southwest Savanna	24	16	40	42	82
Superior Coastal Plain	37	25	62	81	143
Western Coulees and Ridges	82	96	178	130	308
Western Prairie	33	22	55	26	81

(Wisconsin DNR 2005). The SGCN list includes mammals, birds, reptiles, amphibians, fish, and invertebrates (e.g., insects, mussels, and crustaceans) with low and/or declining populations that indicate a potential need for conservation action. (At this time, plants have not been included in this process, but plant SGCN may be identified in the WWAP in the future, as they have in several other states, via a somewhat parallel process.) Animals identified as SGCN are those that are

- already listed as threatened or endangered (at either the federal or state level);
- at risk because of threats to habitats or because some aspect of their life history makes them vulnerable;
- stable in abundance in Wisconsin but declining in adjacent states or nationally; or
- of unknown status in Wisconsin but suspected to be vulnerable to decline or loss.

This subgroup of species was examined separately because of the emphasis placed on them by the WWAP, the prioritization process used by WWAP to identify the best places in the state to manage for SGCN, and the funding sources available to aid in their management. Whenever possible, management should be focused on maintaining, restoring, expanding, or connecting habitats to benefit entire assemblages of organisms.

For vertebrates, teams of experts evaluated each native species using seven criteria that helped define the risk to and conservation needs of each species. The criteria considered were state rarity, state threats, state population trend, global abundance, global distribution, global threats, and global population trend. These criteria are factors that affect the status and population dynamics of a species. For invertebrates, a somewhat parallel methodology to that used for vertebrates was used to determine risk, but the process relied much more heavily on expert opinion due to the paucity of data for most invertebrate species. There are 152 vertebrate and 530 invertebrate SGCN in Wisconsin.

For each vertebrate SGCN, habitats (natural communities, in many cases) needed to sustain populations within Wisconsin were identified by assigning each species a score according to its association with each of the natural communities or other habitats selected for the process. Each of the vertebrate SGCN was also evaluated for its probability of occurring within the 16 ecological landscapes of Wisconsin to identify the best places in the state in which to manage for that SGCN and its habitat. Finally, Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," (see Part 3 of the handbook) was used to identify the best opportunities for management and restoration of each natural community within each ecological landscape. By combining these three scores, "ecological priorities" were assessed using any combination of species, natural communities, or ecological landscapes as a starting point. See the Wisconsin Wildlife Action Plan (Wisconsin DNR 2005) for detailed methodology and a complete listing of all SGCN in Wisconsin.

The Wisconsin Wildlife Action Plan Implementation Team further refined information on which ecological landscapes provide the best opportunities to manage for specific SGCN and its habitat (Wisconsin DNR 2008c). This prioritization work was done for species for which Wisconsin could have a large impact on a SGCN global population; therefore, it is a subset of the original list of SGCN in the Wisconsin Wildlife Action Plan (Wisconsin DNR 2005).

Appendix 3.A is based on the work of the Wisconsin Wildlife Action Plan Implementation Team (WAPIT) and only includes SGCN that were significantly associated with an ecological landscape. The ecological landscapes that have the best management opportunities for a SGCN are highlighted in Appendix 3.A. An "X" that is not highlighted in the appendix indicates other ecological landscapes in which a SGCN occurs. Based on new information compiled since the publication of the Wisconsin Wildlife Action Plan Implementation Report (Wisconsin DNR 2008c), some minor adjustments were made in the appendix that differ from the WAPIT report.

Appendix 3.A is provided to aid managers in identifying those ecological landscapes that are most important for managing a SGCN from a statewide perspective. This does not imply that if there is an absence of highlighting for an "X" or no "X" at all for a SGCN in Appendix 3.A important management opportunities for that species in these ecological landscapes are lacking.

In addition, presenting information for individual SGCN does not imply that single species management is needed or desirable. Instead, managing for a habitat, natural community type, or ecological process may be the best course of action to benefit an entire animal assemblage that includes the SGCN in question. However, any small- or large-scale needs within a habitat or natural community that are required by an individual SGCN (e.g., a microhabitat, or area sensitivity) should be maintained or restored where appropriate and feasible. See the Wisconsin DNR's "Wildlife Action Plan" web page (http://dnr.wi.gov, keyword "wildlife action plan") to learn more about SGCN, their habitats, and the ecological landscapes that they use.

Wildlife Responsibility Species

The concept of "***responsibility species***" was included in this handbook to highlight

1. species that are rare and/or declining and/or with populations that are dependent on Wisconsin for their continued existence (e.g., a relatively high percentage of the global population occurs in Wisconsin, at least during a part of the year);
2. species whose survival in Wisconsin may be at risk; and/or

3. more common species for which Wisconsin provides critical habitat at certain times of the year. Most often these are species that use unusual or localized habitats, concentrate in large numbers during migration or in winter, nest colonially, use communal hibernacula, or are wide-ranging species with low population densities. Both vertebrate and invertebrate species are included.

This subgroup was treated separately to place emphasis on species for which Wisconsin has a regional or continental responsibility to sustain populations, prevent some species from being extirpated from the state, and address key habitats needed by some of the more common species (e.g., migratory bird stopover sites). Here again, management emphasis on the habitat or natural community is often the most efficient and cost effective way to achieve this goal.

Responsibility species that are especially important are those whose populations are dependent on Wisconsin for their continued global existence. For these species, Wisconsin has an important role to play in their global conservation; therefore, these species should receive a high level of management attention. Table 3.13 is a list of vertebrate responsibility species for which Wisconsin plays an especially important role in global conservation (Wisconsin DNR 2005). The species in Table 3.13, plus other responsibility species for which Wisconsin plays an important role in global conservation, are highlighted in Appendix 3.B to indicate their importance.

Ecological landscapes that provide the best habitat management opportunities for responsibility species from a statewide perspective have been identified based on the Wisconsin Wildlife Action Implementation Plan (see Appendix 3.A) (Wisconsin DNR 2008c) and expert opinion. To consider an ecological landscape important for a responsibility species, either a relatively high percentage of the Wisconsin population of that species needs to occur there or good opportunities for effective population protection and habitat management for that species are present in that ecological landscape.

Appendix 3.B compares the best opportunities for managing responsibility species among ecological landscapes. This table is meant to provide a quick summary of which responsibility species are important in which ecological landscapes. Specific management opportunities for responsibility species are presented in the individual ecological landscape chapters. When looking at Appendix 3.B, it is important to keep in mind that there are times when an analysis of responsibility species by ecological landscapes should be interpreted more broadly. Even though a responsibility species may apparently be absent from or undocumented in an ecological landscape in Appendix 3.B, there may still be important management opportunities for that species' habitat there. For example, floodplain forest habitats along large rivers may cross ecological landscape boundaries (and in some cases, connect them in ecologically mean-

Table 3.13. *Vertebrate Responsibility Species with a high relative abundance in Wisconsin compared to the rest of their range.*

Common name	Scientific name
BIRDS[a]	
American Bittern	*Botaurus lentiginosus*
American Woodcock	*Scolopax minor*
Bald Eagle	*Haliaeetus leucocephalus*
Black-billed Cuckoo	*Coccyzus erythropthalmu*
Blue-winged Warbler	*Vermivora pinus*
Bobolink	*Dolichonyx oryzivorus*
Brown Thrasher	*Toxostoma rufum*
Canada Warbler	*Wilsonia canadensis*
Canvasback	*Aythya valisineria*
Connecticut Warbler	*Oporornis agilis*
Eastern Meadowlark	*Sturnella magna*
Field Sparrow	*Spizella pusilla*
Golden-winged Warbler	*Vermivora chrysoptera*
Henslow's Sparrow	*Ammodramus henslowii*
Least Flycatcher	*Empidonax minimus*
Lesser Scaup	*Aythya affinis*
Northern Harrier	*Circus cyaneus*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Veery	*Catharus fuscescens*
Vesper Sparrow	*Pooecetes gramineus*
Whooping Crane	*Grus americana*
Willow Flycatcher	*Empidonax traillii*
HERPTILES	
Blanding's turtle	*Emydoidea blandingii*
Butler's garter snake	*Thamnophis butleri*
FISH[a]	
Blue sucker	*Cycleptus elongates*
Crystal darter	*Ammocrypta (Crystallaria) asprella*
Greater redhorse	*Moxostoma valenciennesi*
Kiyi	*Coregonus kiyi*
Lake sturgeon	*Acipenser fulvescens*
Pugnose shiner	*Notropis anogenus*
Redfin shiner	*Lythrurus umbratilis*
Redside dace	*Clinostomus elongatus*
Shortjaw cisco	*Coregonus zenithicus*
Western sand darter	*Ammocrypta clara*

Source: From Appendix B in Wisconsin's Wildlife Action Plan, Wisconsin's Strategy for Wildlife Species of Greatest Conservation Need (Wisconsin DNR 2005), with the addition of the Whooping Crane and redfin shiner due to more recent data.

Male canvasback. Photo by Wisconsin DNR staff.

ingful ways). A responsibility species (e.g., Red-shouldered Hawk [*Butea lineatus*]) may be ranked as important in one ecological landscape because the largest part of the population occurs there, while the adjoining ecological landscape downstream may not be ranked as important for that species because it has a smaller part of that population even though the same population occupies all parts of a river floodplain that contains suitable, and sometimes contiguous, habitat. Ecological landscape boundaries are not management unit boundaries, though in some (certainly not all) cases, management opportunities for a given habitat and its associated species will be restricted to that ecological landscape.

In addition, presenting a table of responsibility species does not imply that a single-species management approach is needed or desirable. Rather, the approach should be to conserve the habitats and natural communities that responsibility species use, along with the other species that use them.

Socioeconomic Characteristics

Socioeconomic information is summarized below within county boundaries that most closely approximate ecological landscapes unless specifically noted as being based on other factors. Economic data are available only on a political unit basis, generally with counties as the smallest unit for which data are available. Demographic data are presented on a county approximation basis as well since they are often closely associated with economic data.

Land Ownership

The total land and water area of the state of Wisconsin is 35.8 million acres (Table 3.14). The largest of the ecological landscapes in total acreage is the Western Coulees and Ridges, with 6.17 million acres. This ecological landscape is followed in total size by the North Central Forest Ecological Landscape (6.1 million acres), Southeast Glacial Plains Ecological Landscape (4.9 million acres), and Forest Transition Ecological Landscape (4.6 million acres). The smallest ecological landscape is the Northwest Lowlands, with only 431,000 acres.

Forty-seven percent of the state's total area is forested (16.7 million acres) (Table 3.14). The North Central Forest Ecological Landscape has by far the largest acreage in forestland, with 4.8 million acres. This ecological landscape is followed by the Western Coulees and Ridges Ecological Landscape (2.5 million acres), Forest Transition Ecological Landscape (1.9 million acres), and Central Sand Plains Ecological Landscape (1.2 million acres). There are seven ecological landscapes that are more heavily forested on a percentage basis than the statewide average. The most heavily forested is the Northeast Sands Ecological Landscape, which is 84% forested. The North Central Forest Ecological Landscape is close behind (82%), followed by the Northwest Sands Ecological Landscape (78%), Northwest Lowlands Ecological Landscape (77%), and Northern Highland Ecological Landscape (74%). The Southern Lake Michigan Coastal Ecological Landscape is the least forested in both total acres (33,000) and on a percentage basis (6%).

Table 3.14. *Total acres of land and water and forestland by ownership and ecological landscape.*

	All land & water	Forestland					
Ecological landscape	Total	U.S. Forest Service	Other federal	State and local gov.	Total public	Private	Total
Central Lake Michigan Coastal	1,755,089			38,389	38,389	308,547	346,936
Central Sand Hills	1,388,705		3,532	28,992	32,523	562,727	595,250
Central Sand Plains	2,188,861		55,451	450,472	505,923	733,630	1,239,553
Forest Transition	4,658,498	70,689	748	173,03	244,468	1,701,643	1,946,111
North Central Forest	6,107,516	1,099,605	9,089	1,104,193	2,212,886	2,663,791	4,876,678
Northeast Sands	987,176	61,965		255,107	317,072	507,015	824,087
Northern Highland	1,331,970	50,207		344,970	395,177	539,581	934,758
Northern Lake Michigan Coastal	1,282,877			66,800	66,800	422,676	489,476
Northwest Lowlands	431,842		3,181	179,092	182,273	149,465	331,738
Northwest Sands	1,251,723	147,186	7,332	316,120	470,638	511,020	981,658
Southeast Glacial Plains	4,943,731			86,187	86,187	562,622	648,809
Southern Lake Michigan Coastal	539,830			10,646	10,646	22,365	33,011
Southwest Savanna	1,248,126			9,079	9,079	169,695	178,773
Superior Coastal Plain	905,929		22,116	133,513	155,629	434,052	589,681
Western Coulees and Ridges	6,170,674	1,953	69,722	150,496	222,171	2,326,365	2,548,536
Western Prairie	697,633		4,680	11,319	15,999	116,135	132,134
State total	**35,890,180**	**1,431,605**	**175,852**	**3,358,405**	**4,965,862**	**11,731,328**	**16,697,190**

Source: These data are from Forest Inventory and Analysis (USFS 2010) and will differ slightly from earlier area and forestland estimates in this chapter, which were calculated using GIS data.

Interior of old-growth hemlock-hardwood forest, Vilas County. Photo by Eric Epstein, Wisconsin DNR.

Thirty percent of the forestland in Wisconsin is publicly owned (4.9 million acres) (Table 3.14). The ecological landscapes with the highest percentage of forestland owned by the public are in the northern and central sections of the state. They include the Northwest Lowlands (55%), Northwest Sands (48%), North Central Forest (45%), Northern Highland (42%), and Central Sand Plains (41%). The ecological landscape with the lowest percentage of forestland owned by the public is the Southwest Savanna (5%).

Of the 1.5 million acres of forestland owned by the U.S. Forest Service in Wisconsin, over 1 million acres (77%) is in the North Central Forest Ecological Landscape (Table 3.14). The North Central Forest also has 1.1 million acres of the 3.3 million acres of Wisconsin state and county government-owned forestland, twice as much as the next highest total in the Central Sand Plains Ecological Landscape, with 450,472 acres. The North Central Forest Ecological Landscape also has the most privately owned forestland (2.6 million acres) of any ecological landscape. The Western Coulees and Ridges and Forest Transition ecological landscapes follow with 2.5 and 1.9 million acres, respectively.

Resource Characterization and Use[1]

Natural resources are utilized for societal needs. This section discusses how major natural resource groups are used by society in Wisconsin.

Minerals

The U.S. Census Bureau reported from 2007 County Business Patterns data that 140 firms performed a variety of specialized types of mining operations in Wisconsin (USCB 2007). The firms detailed here do not include those engaged in mining support operations. More than one-third of all mining operations in the state are classified in each of two subsectors: Construction Sand and Gravel Mining (53 firms) and Crushed and Broken Limestone Mining and Quarrying (46 firms) (Table 3.15).

Nearly half of all of Wisconsin's mining operations (excluding ***frac sand operations***) are located in the Southeast Glacial Plains counties, with 32 of those firms classified as Construction Sand and Gravel operations and 27 of them classified as Crushed and Broken Limestone Mining and Quarrying operations. Central Lake Michigan Coastal counties support 27 mining operations firms, followed by the Forest Transition counties with 18 mining operations firms. Six of the state's fourteen Dimension Stone Mining and Quarrying firms operate in Central Lake Michigan Coastal counties. Forest Transition counties have more firms operating in Crushed and Broken Granite Mining and Quarrying (5) and Other Crushed and Broken Stone Mining and Quarrying (4) than any other ecological landscape county approximation (Table 3.15). As of December 2011, there were 56 frac sand mines and processing plants active or in development in Wisconsin. Forty of these operations, over 70%, were in the Western Coulees and Ridges Counties (WGNHS 2012).

Water (Ground and Surface)

Water is important as drinking water for people, for industrial uses and thermoregulation at power plants, agriculture, and for recreation and other uses. The data in this section are based on the Wisconsin DNR's 24K Hydrography Geodatabase (Wisconsin DNR 2007), which are the same as the data reported in the "Aquatic Features" section of this chapter; however, the data are categorized differently here so the numbers will differ slightly.

Water Supply

Six of the 16 ecological landscapes have an equal or higher percentage of total area in surface water than the state as a whole (3.5%), including the Northern Highland (13.1%), Southeast Glacial Plains (5.7%), Northwest Sands (5.5%),

[1]When statistics are based on geophysical boundaries (using GIS mapping), the name of the ecological landscape is followed by the term "Ecological Landscape." When statistics are based on county delineation, the name of the ecological landscape is followed by the term "counties."

Table 3.15. *Number of firms in 2007, by mining subsector (excludes support subsectors).*

Ecological landscape county approximations	Mining (excluding support subsectors)	Crude petroleum and natural gas extraction	Gold ore mining	Dimension stone mining and quarrying	Crushed and broken limestone mining and quarrying	Crushed and broken granite mining and quarrying	Other crushed and broken stone mining and quarrying	Construction sand and gravel mining	Industrial sand mining	Kaolin and ball clay mining
Central Lake Michigan Coastal	27	0	0	6	9	2	1	9	0	0
Central Sand Hills	10	0	0	2	3	1	0	3	1	0
Central Sand Plains	5	0	0	1	0	2	0	0	1	1
Forest Transition	18	0	0	3	1	5	4	4	0	1
North Central Forest	7	0	1	0	1	1	1	3	0	0
Northeast Sands	5	0	0	0	1	1	0	2	0	0
Northern Highland	1	0	0	0	0	0	0	1	0	0
Northern Lake Michigan Coastal	7	0	0	0	1	1	0	4	0	0
Northwest Lowlands	2	0	0	0	1	0	1	0	0	0
Northwest Sands	2	0	0	0	1	0	1	0	0	0
Southeast Glacial Plains	68	1	0	5	27	1	1	32	1	0
Southern Lake Michigan Coastal	6	0	0	0	3	0	0	3	0	0
Southwest Savanna	6	0	0	0	3	0	0	3	0	0
Superior Coastal Plain	2	0	0	0	1	0	1	0	0	0
Western Coulees and Ridges	11	0	0	1	4	0	1	3	2	0
Western Prairie	6	0	0	0	2	0	2	1	1	0
Wisconsin	**140**	**1**	**1**	**14**	**46**	**9**	**10**	**53**	**4**	**1**

Source: County business patterns data (USCB 2007).

Central Sand Plains (4.2%), Central Sand Hills (3.6%), and North Central Forest (3.5%). In total surface water area, the Southeast Glacial Plains and the North Central Forest ecological landscapes both have over 200,000 acres (Table 3.16).

As noted above, the Southeast Glacial Plains Ecological Landscape ranks second in percentage of area in water. The vast majority of this water, 93%, is in lakes, with Lake Winnebago making up almost half of this total. The Southwest Savanna Ecological Landscape, with only 2,500 acres in water, ranks lowest in both acreage and percentage of the state total. The Northern Highland Ecological Landscape has the highest percentage of total area in water (13.1%) (Table 3.16).

The Northern Highland, Southeast Glacial Plains, and Northwest Sands ecological landscapes all have over 93% of their surface water in lakes, whereas the Western Coulees and Ridges Ecological Landscape has the highest percentage (66%) in rivers (Wisconsin DNR 2007).

Water Use

The Central Lake Michigan Coastal counties use by far the highest volume of water, over three billion gallons per day. The Southern Lake Michigan Coastal counties are second highest with over two billion gallons per day, and the Southeast Glacial Plains counties rank third with over one billion gallons per day. All three of these ecological landscape county approximations are highly urbanized, which is correlated with higher water usage. The counties of the Northwest Lowlands Ecological Landscape, which has low population density, use the least amount of water at about seven million gallons per day (Table 3.17).

The Southeast Glacial Plains counties rank highest in domestic, commercial, and agricultural water usage (USGS 2009). The Central Sand Plains and Central Sand Hills counties rank highest for irrigation use. The Forest Transition counties use the most water for industrial purposes, and the Central Lake Michigan Coastal counties rank highest in water usage for thermoelectric power generation.

Recreation

In Wisconsin, natural resources are an important component of recreation for people. Below are some of the important recreation activities that utilize natural resources.

Campgrounds and Campsites

The larger ecological landscape county approximations have a higher number of campgrounds, but regions with a higher proportion of public or recreational land have higher densities. For instance, the North Central Forest and Forest Tran-

Table 3.16. *Water supply (millions of gallons per day) by ecological landscape.*

Ecological Landscape	Total surface water (acres)	Percent of total area in surface water	Percent of state total surface water
Central Lake Michigan Coastal	17,190	1.0	1.3
Central Sand Hills	50,394	3.6	4.0
Central Sand Plains	92,181	4.2	7.2
Forest Transition	114,953	2.5	9.0
North Central Forest	211,804	3.5	16.6
Northeast Sands	30,445	3.1	2.4
Northern Highland	173,953	13.1	13.6
Northern Lake Michigan Coastal	19,526	1.5	1.5
Northwest Lowlands	10,519	2.4	0.8
Northwest Sands	69,141	5.5	5.4
Southeast Glacial Plains	282,680	5.7	22.2
Southern Lake Michigan Coastal	9,074	1.7	0.7
Southwest Savanna	2,513	0.2	0.2
Superior Coastal Plain	16,168	1.8	1.3
Western Coulees and Ridges	159,387	2.6	12.5
Western Prairie	14,678	2.1	1.2
State total	**1,274,606**	**3.5**	**100.0**

Source: Data from Wisconsin DNR 24k Hydrography Geodatabase (Wisconsin DNR 2012a). Available online at http://dnr.wi.gov/maps/gis/datahydro.htm and also accessible via the Surface Water Data Viewer, http://dnr.wi.gov/, keyword "surface water."

Table 3.17. *Water use (millions of gallons per day) by ecological landscape county approximation.*

Ecological landscape county approximations	Water use[a] (million gallons per day)	Water use per capita[a] (gallons per day)
Central Lake Michigan Coastal	3,255.3	4,610
Central Sand Hills	134.9	759
Central Sand Plains	274.5	983
Forest Transition	473.3	786
North Central Forest	96.4	342
Northeast Sands	29.3	330
Northern Highland	35.1	543
Northern Lake Michigan Coastal	39.4	320
Northwest Lowlands	6.7	155
Northwest Sands	16.8	186
Southeast Glacial Plains	1,190.8	632
Southern Lake Michigan Coastal	2,046.8	1,601
Southwest Savanna	264.4	2,165
Superior Coastal Plain	45.7	608
Western Coulees and Ridges	894.2	885
Western Prairie	11.9	80
State total	**8,815.5**	**1,615**

Source: Based on 1995 values taken from the U.S. Geological Survey on water uses in Wisconsin counties (USGS 2009).

[a]Both water use and population are calculated by county.

sition counties have the greatest number of campgrounds, whereas the Northern Highland counties have the highest density of campgrounds (Table 3.18).

The greatest number of campsites occurs in the Southeast Glacial Plains and the Western Coulees and Ridges county approximations, but the highest density of campsites occurs in the Central Sand Hills counties. There are several popular tourist areas in the region, including Wisconsin Dells, Devil's Lake State Park, and Hartman Creek State Park. The ecological landscape county approximations with the lowest density of campsites include the Superior Coastal Plain and North Central Forest counties (Table 3.18).

Miles of Trails

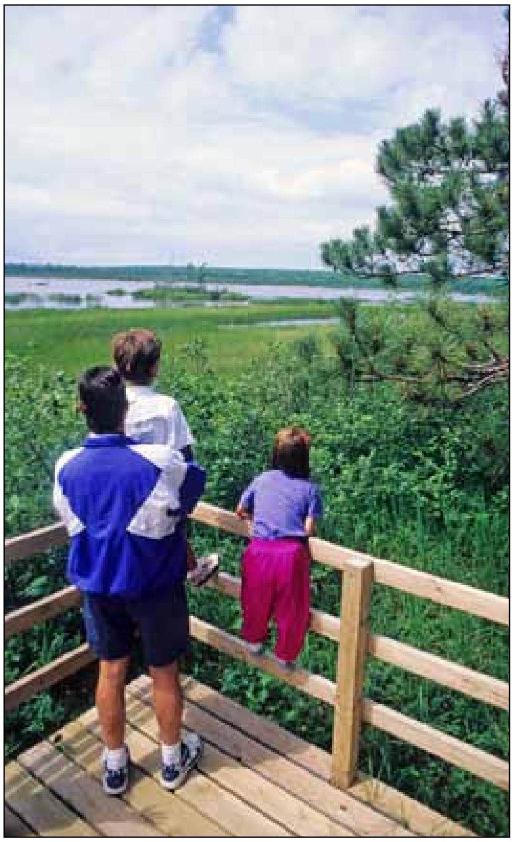
In general, highly urbanized regions will have more hiking and biking trails, and highly forested counties will have a higher proportion of motorized trails as well as ski trails. For instance, the Southeast Glacial Plains counties rank highest in miles of hiking and biking trails, and the Southern Lake Michigan Coastal counties rank highest in density (miles of trail per 100 square miles of land area) of hiking and biking trails (Table 3.19). The counties of the Forest Transition and North Central Forest ecological landscapes both rank highest in miles of snowmobiling, skiing, and ATV trails because of their large acreage in forest. The Northwest Lowlands counties have the highest density of ATV trails. The Northern Highland counties, which have a large acreage of public land, also have the highest density of ski and snowmobiling trails. For all trails combined, the Forest Transition counties have the highest mileage, but the Northern Lake Michigan Coastal counties have the highest density of trails with a good distribution of all types of trails.

Skiing a cross-country trail. Photo by Wisconsin DNR staff.

Table 3.18. *Number and density of campgrounds and campsites by ecological landscape county approximation.*

Ecological landscape county approximations	Campgrounds (public & private)	Density of campgrounds (per 100 sq. mi.)	Campsites (public & private)	Density of campsites (per 100 sq. mi.)
Central Lake Michigan Coastal	74	1.9	5,802	148.5
Central Sand Hills	82	2.7	8,114	270.7
Central Sand Plains	132	2.2	9,758	160.0
Forest Transition	253	2.0	12,544	99.4
North Central Forest	266	2.1	8,367	65.9
Northeast Sands	64	2.0	2,303	71.0
Northern Highland	86	3.2	4,465	163.7
Northern Lake Michigan Coastal	100	2.7	6,627	175.7
Northwest Lowlands	36	2.8	1,313	101.0
Northwest Sands	129	2.9	4,305	98.1
Southeast Glacial Plains	204	2.1	18,837	197.3
Southern Lake Michigan Coastal	18	2.1	1,656	196.6
Southwest Savanna	43	1.4	2,989	96.0
Superior Coastal Plain	79	2.1	2,393	62.8
Western Coulees and Ridges	204	1.7	15,077	126.5
Western Prairie	23	1.8	1,600	123.4

Source: 2005–2010 Wisconsin Statewide Comprehensive Outdoor Recreation Plan (SCORP) (Wisconsin DNR 2006).



Nature appreciation on the boardwalk of Big Bay State Park, on Madeline Island. Photo by Wisconsin DNR staff.

Number of Visits to State-Owned Recreation Facilities

The Southeast Glacial Plains Ecological Landscape has the highest total number of visitors to state-owned facilities, about 3.7 million in 2006 (WLRB 2007-2008). Kettle Moraine State Forest, southern and northern units, was a major draw for tourists from the urbanized areas of southeast Wisconsin, but several state parks in this area also drew large numbers of visitors. The Western Coulees and Ridges Ecological Landscape saw the greatest number of state park visitors, almost 2.7 million. The popular parks in this landscape include Devil's Lake, Governor Dodge, Wildcat Mountain, and Wyalusing state parks. State parks accounted for over 70% of all visitors, whereas visitors to state forests made up almost 20%.

Agriculture

Agriculture is a very important use of the land in Wisconsin, especially southern Wisconsin. This section describes the importance of agriculture in the different ecological landscapes.

Table 3.19. *Miles and density of trails by trail type and ecological landscape county approximation.*

Ecological landscape county approximation	Hiking trails		Biking trails[a]		ATV trails		Skiing trails		Snowmobiling trails		Total all trails	
	Miles	Density (/100 mi²)	Miles	Density (/100 mi²)	Miles	Density (/100 mi²)	Miles	Density (/100 mi²)	Miles	Density (/100 mi²)	Miles	Density (/100 mi²)
Central Lake Michigan Coastal	157	4.0	413	9.4	20	0.5	220	5.6	1,455	37.2	2,219	56.8
Central Sand Hills	67	2.2	130	3.4	–	0.0	126	4.2	936	31.2	1,230	41.0
Central Sand Plains	155	2.5	541	6.7	425	7.0	300	4.9	1,832	30.0	3,120	51.2
Forest Transition	329	2.6	821	4.8	2,916	23.1	819	6.5	4,374	34.7	9,042	71.6
North Central Forest	91	0.7	581	3.1	2,133	16.8	976	7.7	4,049	31.9	7,644	60.2
Northeast Sands	33	1.0	114	2.0	515	15.9	127	3.9	1,016	31.3	1,755	54.1
Northern Highland	76	2.8	258	6.7	286	10.5	552	20.2	1,098	40.3	2,194	80.4
Northern Lake Michigan Coastal	118	3.1	439	8.5	999	26.5	263	7.0	1,483	39.3	3,184	84.4
Northwest Lowlands	51	3.9	196	9.1	373	28.7	132	10.2	300	23.1	974	74.9
Northwest Sands	66	1.5	392	5.6	895	20.4	426	9.7	1,206	27.5	2,841	64.7
Southeast Glacial Plains	592	6.2	1,182	10.5	20	0.2	758	7.9	2,927	30.7	5,298	55.5
Southern Lake Michigan Coastal	62	7.4	331	34.2	–	0.0	123	14.6	235	27.9	708	84.0
Southwest Savanna	26	0.6	197	3.7	36	0.8	206	4.8	612	14.2	1,041	24.2
Superior Coastal Plain	84	2.2	288	5.0	634	16.6	361	9.5	934	24.5	2,204	57.8
Western Coulees and Ridges	178	1.5	757	4.8	164	1.4	452	3.8	2,806	23.5	4,177	35.0
Western Prairie	21	1.6	76	5.2	–	0.0	39	3.0	439	33.8	566	43.6
State total	1,507	2.8	2,596	4.8	5,027	9.3	3,882	7.2	16,860	31.2	30,899	57.1

Source: Wisconsin State Forests, Parks, Trails and Recreation Areas, Wisconsin Blue Book 2007–2008 (WLRB 2007–2008).

[a]Includes road and mountain biking trails.

Acres of Farmland

The Southeast Glacial Plains (3.3 million acres) and Western Coulees and Ridges (3 million acres) ecological landscapes have the highest acreage in farmland, using either the geographic or county delineation (Table 3.20). The Southwest Savanna and the Western Prairie ecological landscapes have the highest percentage of land in agriculture, 81% and 70%, respectively. The Northern Highland and the Northwest Lowlands ecological landscapes have the lowest acreages in agriculture, less than 50,000 acres each. The Northern Highland Ecological Landscape has the lowest percentage of land in agriculture, about 4%.

Farm Income

The Southeast Glacial Plains counties have the highest net cash farm income of operation ($430 million) and the Northwest Lowlands counties have the lowest (<$1 million) (Table 3.21). The average income per agricultural acre was highest in the Central Lake Michigan Coastal counties where milk production is very important. The Southeast Glacial Plains counties account for 23% of all agricultural land but only 18% of milk production, whereas the Central Lake Michigan Coastal counties make up only 9% of all farmland but 12% of milk production. The average income per acre was lowest in the Northwest Lowlands counties with a value of slightly less than the cost of production.

Table 3.20. *Estimated acres of farmland by ecological landscape county approximation, 2006.*

Ecological landscape county approximation	Geographic delineation[a] (thousand acres)	Percent all land	County delineation (thousand acres)	Percent all land
Central Lake Michigan Coastal	1,292	74	1,560	62
Central Sand Hills	745	56	1,127	59
Central Sand Plains	602	29	1,895	49
Forest Transition	2,117	47	3,652	45
North Central Forest	621	11	1,546	19
Northeast Sands	132	14	389	19
Northern Highland	48	4	73	4
Northern Lake Michigan Coastal	725	57	773	32
Northwest Lowlands	47	11	85	10
Northwest Sands	128	11	400	14
Southeast Glacial Plains	3,373	72	3,945	65
Southern Lake Michigan Coastal	295	56	218	41
Southwest Savanna	1,001	80	1,623	81
Superior Coastal Plain	177	20	255	10
Western Coulees and Ridges	3,064	51	5,186	68
Western Prairie	533	78	577	70

Source: County-level data for farms, National Agricultural Statistics Services (NASS 2009).

[a]Based on WISCLAND land cover types including agriculture and grassland (Wisconsin DNR 1993).

Table 3.21. *Net cash farm income of operation and income per farmed acre by ecological landscape county approximation, 2002.*

Ecological landscape county approximation	Net cash farm income (millions of dollars)	Average income per agricultural acre
Central Lake Michigan Coastal	$226	$145
Central Sand Hills	$94	$83
Central Sand Plains	$178	$94
Forest Transition	$330	$90
North Central Forest	$96	$62
Northeast Sands	$26	$66
Northern Highland	$4	$52
Northern Lake Michigan Coastal	$72	$94
Northwest Lowlands	$0	<$1
Northwest Sands	$10	$24
Southeast Glacial Plains	$430	$109
Southern Lake Michigan Coastal	$26	$120
Southwest Savanna	$132	$81
Superior Coastal Plain	$4	$15
Western Coulees and Ridges	$395	$76
Western Prairie	$35	$76

Source: County-level data for farms, National Agricultural Statistics Services (NASS 2009).

Timber

Timber is a very important part of Wisconsin's economy, and this industry has a large impact on the natural resources of the state. Below is a description of the timber resources and uses in the state.

Supply – Volume and Growth

The North Central Forest Ecological Landscape has the largest acreage in timberland, almost 5 million acres (Table 3.22): 82% of total land area of the ecological landscape and about 30% of all timberland in the state. This ecological landscape produces the most growing stock volume but is only about average in terms of productivity per acre. The southern part of the state bordering Lake Michigan is the most productive; the Central Lake Michigan Coastal Ecological Landscape produces about 1,700 cubic feet per acre of growing stock volume, and the Southern Lake Michigan Coastal Ecological Landscape produces over 1,500 cubic feet per acre. However, the Southern Lake Michigan Coastal Ecological Landscape has the lowest acreage in timberland, only about 35,000 acres, and the lowest volume of growing stock. The least productive region of the state is the Northwest Sands and the Superior Coastal Plain ecological landscapes.

Demand – Removals

The North Central Forest Ecological Landscape has by far the highest volumes of growth and removals of timber due to its total land area and amount of forested acreage (Table 3.23). The Southern Lake Michigan Coastal Ecological Landscape, a small ecological landscape with very little forest, has the lowest volumes of growth and removals. The ratio of removals to growth is highest in the Northwest Lowlands Ecological Landscape. Removals of aspen are very high, and mortality, due primarily to insects and diseases, of key species like spruce (*Picea* spp.) and balsam fir (*Abies balsamea*) exceeds growth. The lowest ratio of removals to growth occurs in the Western Prairie Ecological Landscape where growth rates are high but not much timber is harvested.

Infrastructure

The infrastructure is important to the socioeconomic conditions of the state for the transportation of people and goods. Below is a comparison of the infrastructure among the ecological landscapes in the state.

Transportation

Since many transportation modes are related to population, it makes sense that the highest density of roads, railroads, and airports would be located in the areas of highest population density. The Southern Lake Michigan Coastal counties have the highest population density (1,548 people per square mile compared to a statewide average of 105 people per square mile) as well as the highest density of roads, railroads, and airport runways. The Southeast Glacial Plains counties, which form the largest landscape in the more urban and agricultural southern part of the state, have the highest mileage of roads, railroads, and airport runways as well as the highest number of airports (Table 3.24). The ecological landscape county approximations with the lowest density of roads, railroads, and airport runways are the Northwest Lowlands, North Central Forest, and Southwest Savanna counties. The Northwest Lowlands counties have the lowest population density.

Renewable Energy

Wind. The highest wind densities (a measure of wind power output) occur in four ecological landscapes in southern Wisconsin: the Central Lake Michigan Coastal, the Southeast Glacial Plains, the Southern Lake Michigan Coastal, and

Commercial wind facility in southeastern Wisconsin. Wind energy is growing in Wisconsin in recent years, but commercial wind facility siting is controversial and requires careful evaluation from both environmental and socioeconomic perspectives. Photo by Ryan O'Connor, Wisconsin DNR.

The busy twin ports of Duluth and Superior have been used for over a century to transport materials for a variety of industries across the Great Lakes. Wisconsin's ports are economically important; each year, about 40 million tons of goods worth over $8 billion pass through Wisconsin's commercial ports (Wisconsin DOT 2010). Although transportation by water is energy efficient relative to other forms, it has facilitated the spread of invasive species from other parts of the world. Photo By Eric Epstein, Wisconsin DNR.

Table 3.22. *Estimated acreage, volume, and growth on timberland by ecological landscape, 2006.*

Ecological landscape	Timberland acreage	Growing stock volume (cubic feet)	Volume per acre (cubic feet)
Central Lake Michigan Coastal	333,224	562,149,754	1,687
Central Sand Hills	472,936	659,385,538	1,394
Central Sand Plains	1,250,801	1,289,665,995	1,031
Forest Transition	2,010,322	2,870,996,539	1,428
North Central Forest	4,821,568	6,094,639,705	1,264
Northeast Sands	803,536	1,127,386,074	1,403
Northern Highland	934,003	1,171,746,127	1,255
Northern Lake Michigan Coastal	459,127	619,331,220	1,349
Northwest Lowlands	314,231	336,144,555	1,070
Northwest Sands	958,496	916,831,367	957
Southeast Glacial Plains	590,779	724,060,646	1,226
Southern Lake Michigan Coastal	35,389	55,070,277	1,556
Southwest Savanna	169,413	203,938,863	1,204
Superior Coastal Plain	583,058	596,040,119	1,022
Western Coulees and Ridges	2,549,900	3,174,915,718	1,245
Western Prairie	121,188	158,804,747	1,310
State total	**16,407,970**	**20,561,107,245**	**1,253**

Source: Data from 2007 Forest Inventory and Analysis (USFS 2010).

Table 3.23. *Average annual removals and growth of growing stock on timberland and ratio of removals to growth by ecological landscape.*

Ecological landscape	Average annual removals (thousand cubic feet)	Average annual growth (thousand cubic feet)	Ratio of removals to growth
Central Lake Michigan Coastal	2,601	16,674	16%
Central Sand Hills	15,046	20,278	74%
Central Sand Plains	30,343	39,767	76%
Forest Transition	48,264	87,250	55%
North Central Forest	91,500	148,963	61%
Northeast Sands	19,578	36,887	53%
Northern Highland	26,684	32,270	83%
Northern Lake Michigan Coastal	6,306	16,907	37%
Northwest Lowlands	11,580	11,004	105%
Northwest Sands	15,980	36,235	44%
Southeast Glacial Plains	12,103	19,520	62%
Southern Lake Michigan Coastal	775	2,278	34%
Southwest Savanna	994	2,943	34%
Superior Coastal Plain	7,181	14,862	48%
Western Coulees and Ridges	58,685	95,304	62%
Western Prairie	1,612	10,766	15%
State total	**349,231**	**591,906**	**59%**

Source: Data from 2007 Forest Inventory and Analysis (USFS 2010).

the Southwest Savanna ecological landscapes. All have areas where the mean annual power density at 40 meters is over 500 watts per square mile. As of 2012, the Southeast Glacial Plains Ecological Landscape has six wind farms, the Central Lake Michigan has four wind farms, and the Southwest Savanna has one wind farm (WWIC 2012).

Biomass. Woody biomass is Wisconsin's most used renewable energy resource. However, to ensure that woody biomass harvests are done in a sustainable manner, the Wisconsin DNR's *Wisconsin's Forestland Woody Biomass Harvesting Guidelines* (Herrick et al. 2009) should be consulted. See the discussion of forest and woody biomass issues in the "Bioenergy" section in Chapter 5 for more details. As would be expected, the woody biomass volume is concentrated in the northern half of the state where the bulk of the forest resource and timber harvest occur. The North Central Forest counties produce the most logging residue of any ecological landscape county approximation in the state. The North Central Forest counties' forests annually produce over 73 million cubic feet of logging residue (Table 3.25) or 47% of total statewide production. Not surprisingly, the Southern Lake Michigan Coastal counties annually produce the least logging residue (79,125 cubic feet) of all ecological land-

Table 3.24. *Road miles and density, railroad miles and density, number of airports, airport runway miles and density, and number of ports by ecological landscape county approximation.*

Ecological landscape county approximation	Miles of roads	Road density[a]	Miles of railroads	Railroad density[b]	Number of airports	Miles of runway	Runway density[c]	Number of ports[d]
Central Lake Michigan Coastal	12,376	4.6	489	18.0	7	6.5	2.4	4
Percent state total	7%	133%	9%	186%	5%	7%	135%	29%
Central Sand Hills	7,270	3.5	156	7.5	5	2.8	1.3	0
Percent state total	4%	101%	3%	77%	4%	3%	76%	0%
Central Sand Plains	10,921	3.3	368	11.2	8	6.5	2.0	0
Percent state total	6%	97%	7%	116%	6%	7%	112%	0%
Forest Transition	22,692	3.2	556	7.8	14	10.4	1.5	0
Percent state total	12%	93%	11%	81%	11%	11%	83%	0%
North Central Forest	20,667	2.2	535	5.8	8	5.1	0.5	0
Percent state total	11%	65%	10%	60%	6%	5%	31%	0%
Northeast Sands	5,230	3.5	132	8.8	3	1.5	1.0	0
Percent state total	3%	102%	3%	91%	2%	2%	56%	0%
Northern Highland	6,770	3.7	78	4.3	8	6.7	3.7	0
Percent state total	4%	109%	1%	45%	6%	7%	209%	0%
Northern Lake Michigan Coastal	7,212	3.7	218	11.0	5	2.9	1.4	3
Percent state total	4%	107%	4%	114%	4%	3%	82%	21%
Northwest Lowlands	1,353	2.1	26	4.0	0	0	0	0
Percent state total	1%	60%	1%	41%	0%	0%	0%	0%
Northwest Sands	7,329	4.0	99	5.3	5	3.4	1.9	0
Percent state total	4%	116%	2%	55%	4%	4%	105%	0%
Southeast Glacial Plains	31,392	4.3	1,193	16.4	31	22.7	3.1	0
Percent state total	17%	126%	23%	169%	24%	24%	176%	0%
Southern Lake Michigan Coastal	8,795	10.6	317	38.3	6	5.6	6.8	1
Percent state total	5%	309%	6%	396%	5%	6%	383%	7%
Southwest Savanna	6,107	3.1	54	2.8	3	1.8	0.9	0
Percent state total	3%	91%	1%	29%	2%	2%	52%	0%
Superior Coastal Plain	3,842	2.8	165	11.9	3	2.5	1.8	4
Percent state total	2%	81%	3%	123%	2%	3%	102%	29%
Western Coulees and Ridges	29,890	3.2	752	8.0	20	16.3	1.7	2
Percent state total	16%	93%	14%	83%	16%	17%	98%	14%
Western Prairie	3,640	3.4	94	8.8	2	1.1	1.0	0
Percent state total	2%	99%	2%	91%	2%	1%	56%	0%
State total	**185,486**	**3.4**	**5,232**	**9.6**	**128**	**95.8**	**1.7**	**14**

Note: These data are for county approximations of the ecological landscapes. As a result, some counties are included in more than one ecological landscape county approximation; therefore, they do not add up to the state total.

[a]Miles of road per square mile of land. Data from Wisconsin Roads 2000 TIGER line files (dataset), Wisconsin Department of Administration, Office of Land Administration Services (Wisconsin DOA 2000).

[b]Miles of railroad per 100 square miles of land. Data from 1:100,000-scale Rails Chain Database (Wisconsin DOT 1998).

[c]Miles of airport runway per 1,000 square miles of land. From Wisconsin Airport Directory 2011–2012 web page (Wisconsin DOT 2012).

[d]Data from Wisconsin DOT Bureau of Planning and Economic Development, map of Wisconsin's commercial ports (Wisconsin DOT 2010).

Table 3.25. *Volume of logging residue (cubic feet) by ecological landscape county approximation, 2007.*

Ecological landscape county approximation	Cubic feet
Central Lake Michigan Coastal	3,659,537
Central Sand Hills	4,580,965
Central Sand Plains	17,093,993
Forest Transition	49,045,725
North Central Forest	73,416,896
Northeast Sands	17,873,549
Northern Highland	14,039,691
Northern Lake Michigan Coastal	15,131,025
Northwest Lowlands	4,498,944
Northwest Sands	17,736,879
Southeast Glacial Plains	3,849,082
Southern Lake Michigan Coastal	79,125
Southwest Savanna	2,284,344
Superior Coastal Plain	18,947,492
Western Coulees and Ridges	18,247,871
Western Prairie	949,571
State total	**155,867,732**

Source: Forest Inventory and Analysis, Timber Product Output Mapmaker, Version 1.0 (web application) (USFS 2007).

Note: These data are for county approximations of the ecological landscapes. As a result, some counties are included in more than one ecological landscape county approximation; therefore, they do not add up to the state total.

scape county approximations in the state. However, there are opportunities for harvesting nonforest biomass such as corn and soybeans for liquid fuels and burning crop residues or bioenergy crops to produce power in southern Wisconsin. See "Agriculture Bioenergy" in the "Bioenergy" section of Chapter 5 for more discussion on the sustainability of using nonforest biomass, as well as a report entitled "Wisconsin Sustainable Planting and Harvesting Guidelines for Nonforest Biomass on Public and Private Lands" (Hull et al. 2011) to ensure that nonforest biomass growing and harvesting is done in a sustainable manner.

Human Demography

Wisconsin's statewide population in 2010 was nearly 5.7 million, according to the 2010 census, with over 37% (over two million) of the population residing in counties in the Southeast Glacial Plains Ecological Landscape (Table 3.26). Nearly one quarter (1.3 million) of the statewide population resided in the Southern Lake Michigan Coastal counties in 2010. Though population growth and urbanization are occurring in Wisconsin, the state retains much of it rural character, with nearly one-third of its population classified as rural (Table 3.26). The Southern Lake Michigan Coastal counties, encompassing the Milwaukee metro area, are almost entirely urban. Only three other ecological landscapes have less than half of their population rural: Southeast Glacial Plains counties (26.8% rural population), Central Lake Michigan Coastal counties (29.5%), and Northwest Lowlands counties (38.4%). (The Northwest Lowlands counties are very rural except for the City of Superior, which biases these data.) The ecological landscapes with the greatest proportion of rural population are largely in the northern part of the state, with the exception of the Southwest Savanna counties, with over 70% of its population classified as rural.

Wisconsin's statewide population density was 105 persons per square mile in 2010, but only three ecological landscape county approximations have population densities exceeding the statewide average: Southern Lake Michigan Coastal (1,548 persons per square mile), Southeast Glacial Plains (223), and Central Lake Michigan Coastal (212) (Table 3.26). The North Central Forest, the Northwest Sands, and the Superior Coastal Plain are the most sparsely populated ecological landscape county approximations in the state, with roughly 20 persons per square mile.

Ecological landscape county approximations in the north tend to have an older population structure than those in more urban areas of the south and west. The Northern Highland counties had 23.5% of their population aged 65 and older in 2010 (Table 3.26). In contrast, the Western Prairie counties have just over 10% of their population aged 65 or older. The Southeast Glacial Plains, Central Lake Michigan Coastal, and Southern Lake Michigan Coastal counties also have a notably lower percentage of their population aged 65 and older, associated with their higher level of urban influence and the economic opportunities that come with that character. Ecological landscapes with more rural character tend to have higher proportions of their population aged 65 or older.

Population growth rates tend to be higher in ecological landscapes with considerable suburban character as Wisconsin's population flows outward from urban centers. The Western Prairie counties, influenced heavily by the expansion of the Twin Cities metro area, have experienced especially sharp population growth, at over 25% from 2000 to 2010 (Table 3.26). Population growth is also relatively high in the Southeast Glacial Plains counties (8.8%), Western Coulees and Ridges counties (6.7%), and the Central Lake Michigan Coastal counties (6.7%). Rural, northern ecological landscape county approximations, such as the Superior Coastal Plain counties (0.2%), North Central Forest counties (0.6%), and Northwest Sands counties (0.6%), have experienced the least population growth from 2000 to 2010. Populations in the Northern Highland counties (-2.1%) and Northeast Sands counties (-0.7%) have declined from 2000 to 2010.

Housing

Housing density in 2010 in Wisconsin was 48.5 homes per square mile but unevenly distributed across the state (Table 3.27). The Southern Lake Michigan Coastal counties, encompassing the Milwaukee metro area, had by far the highest housing density statewide, at 673 per square mile. The only other ecological landscape county approximations with housing density higher than the state average in 2010 were the Southeast Glacial Plains counties (with the Madison metro area and portions of the extended Milwaukee metro area and the Fox Valley) and the Central Lake Michigan Coastal counties (with the Green Bay metro area and portions of the Fox Valley). Housing density was lowest in the Superior Coastal Plain (11.9), North Central Forest (12.4), and Northwest Sands (14.6) counties. The rest of the ecological landscape county approximations ranged from 17.5 to 38.7 homes per square mile in 2010.

Housing growth is much more variable, with more nuanced factors affecting which ecological landscapes experience the most growth. The Western Prairie's St. Croix and Pierce counties had the highest combined housing growth from 2000 to 2007 at 17.3%, followed by the Central Lake Michigan Coastal counties (14.4%) and Southeast Glacial Plains counties (13.5%) (Table 3.27). The lowest level of housing growth for the same period occurred in the highly urbanized Southern Lake Michigan Coastal counties. Most housing development in the Milwaukee metro area has occurred at its geographical fringes in the Central Lake Michigan Coastal and Southeast Glacial Plain counties. This is similar to what has occurred in the Western Prairie counties on the fringe of the Twin Cities Metro area. However, rural northern ecological landscape county approximations such as the Northwest Lowlands (5.7%) and Superior Coastal Plain counties (7.7%) also saw relatively slow housing growth, indicating relatively stable local economies in their counties.

Prevalence of seasonal housing is highly correlated to tourism and higher property values, which can be important economic drivers, especially for rural local economies with few other strong economic sectors. Seasonal housing is highly variable throughout the state. Percent seasonal housing is generally lower in more urban ecological landscapes than in rural ecological landscapes, especially in the north where forests and lakes are principle attractants to nonresident housing. Over 40% of all housing in the Northern Highland counties was classified as seasonal in 2010 (Table 3.27). The Northern Lake Michigan Coastal (32.1% seasonal housing), Northeast Sands (29.7%), Northwest Sands (28.6%), North Central Forest (20.4%), and Superior Coastal Plain (20.8%) counties complete a band of relatively high seasonal housing rates across the northern portion of the state.

Economy

Data presented below are from before the recession that began in 2008. Therefore, the actual statistics may have changed in the last few years; however, large-scale trends should still hold true.

Per capita income is generally used as a proxy for a region's overall standard of living. Wisconsin's per capita income statewide in 2006 was $34,405 (Table 3.28), but per capita income is highly correlated with urban influence. The Southeast Glacial Plains ($38,934) and Central Lake Michigan Coastal counties ($36,555) are the only two ecological landscape county approximations with per capita incomes higher than the statewide average, indicating their relatively high influence on the overall economy of the state compared to other ecological landscape county approximations. Per capita income is also moderately high in the Southern Lake Michigan Coastal ($34,019) and Western Prairie ($32,907) counties, with both having high levels of urban influence on their economies. As with many other economic indicators, per capita income is generally lowest in the northern ecological landscape county approximations. The Northwest Sands ($26,208), Northwest Lowlands ($26,396), Superior Coastal Plain ($26,597), and the North Central Forest ($26,738) counties all have per capita incomes more than 20% lower than the statewide average. Notably, the Northern Highland counties ($31,593) rank relatively high compared to its northern neighbors, perhaps as a result of its relatively robust tourism industry and prevalence of second homes.

Average earnings per job in Wisconsin in 2006 were $36,142 (Table 3.28). The Southern Lake Michigan Coastal counties ($40,675) had the highest average earnings per job, followed by the Southeast Glacial Plains counties ($37,551) and Central Lake Michigan Coastal counties ($35,826). Though its per capita income ranked higher than its northern neighbors, the Northern Highland counties had the lowest average earnings per job ($27,444) in the state, largely because of its dependence on seasonal and part-time jobs associated with tourism. Other ecological landscape county approximations with relatively low average earnings per job were Northern Lake Michigan Coastal, Southwest Savanna, North Central Forest, Northwest Sands, and Northeast Sands counties.

Although the unemployment rates presented below are from before the recession that started in 2008, and current unemployment rates are higher, the large-scale trends in unemployment still hold true. In 2006, low unemployment rates were concentrated in the southern ecological landscape county approximations (Table 3.28); the Southeast Glacial Plains (4.1%), Western Coulees and Ridges (4.3%), Southwest Savanna (4.4%), and Central Lake Michigan Coastal (4.4%) counties were all below the statewide level. Unemployment was particularly high in northern ecological landscape county approximations, especially in the Northeast Sands (6.5%) and the Northern Highland counties (6.1%). Notably, the Southern Lake Michigan Coastal counties had relatively high unemployment (5.6%) in contrast to neighboring ecological landscape county approximations.

Wisconsin's overall poverty rate was estimated at 10.2% in 2005 but was highly variable throughout the state (Table 3.28). Southern Lake Michigan Coastal counties had by far the highest poverty rate (15.2%) in spite of its high earnings per job figure. This discrepancy points to both abundant high-paying white collar jobs driving up the average wage figures and populations of urban poor and unemployed. Other ecological landscape county approximations with high poverty rates tended to be concentrated in the northwest. The

Table 3.26. *Total population, percent rural population (2000), population density per square mile, percent population age 65 and over, and percent population growth rate by ecological landscape county approximation in 2010.*

Ecological landscape county approximation	Total population	Percent rural population in 2000[a]	Population density per square mile	Percent age 65 and over	Percent population growth rate (2000–2010)
Wisconsin	**5,686,986**	**31.7**	**105**	**13.7**	**6.0**
Central Lake Michigan Coastal	830,001	29.5	212	13.5	6.7
Central Sand Hills	186,803	63.1	62	15.6	4.5
Central Sand Plains	292,119	57.7	48	15.8	4.6
Forest Transition	649,992	58.5	51	16.0	3.7
North Central Forest	244,020	71.5	19	18.1	0.6
Northeast Sands	88,064	72.3	27	17.8	-0.7
Northern Highland	63,344	81.7	23	23.5	-2.1
Northern Lake Michigan Coastal	149,143	71.0	40	18.9	1.0
Northwest Lowlands	44,159	38.4	34	14.4	2.0
Northwest Sands	90,541	67.4	21	18.1	0.6
Southeast Glacial Plains	2,129,491	26.8	223	13.3	8.8
Southern Lake Michigan Coastal	1,309,569	3.5	1,548	11.7	2.4
Southwest Savanna	128,573	70.9	41	15.0	5.2
Superior Coastal Plain	75,330	54.1	20	16.0	0.2
Western Coulees and Ridges	614,553	51.7	57	14.2	6.7
Western Prairie	125,364	58.6	97	10.1	25.4

Source: U.S. Census Bureau (USCB 2010).
[a]Percent rural population uses 2000 data because more recent data were not available at the time of this writing.

Table 3.27. *Housing density per square mile (in 2010), housing growth (2000–2007), and percent seasonal housing (in 2010) by ecological landscape county approximation.*

Ecological landscape county approximation	Housing density per square mile in 2010	Percent housing growth 2000–2007	Percent seasonal housing in 2010
Wisconsin	**48.5**	**10.3**	**6.3**
Central Lake Michigan Coastal	91.1	14.4	2.0
Central Sand Hills	30.5	9.6	11.0
Central Sand Plains	23.0	10.2	8.8
Forest Transition	24.7	10.2	10.3
North Central Forest	12.4	9.8	20.4
Northeast Sands	18.8	10.8	29.7
Northern Highland	22.5	9.4	41.6
Northern Lake Michigan Coastal	26.1	10.7	32.1
Northwest Lowlands	17.5	5.7	8.8
Northwest Sands	14.6	9.6	28.6
Southeast Glacial Plains	97.0	13.5	3.1
Southern Lake Michigan Coastal	673.3	4.5	0.6
Southwest Savanna	17.7	9.1	3.0
Superior Coastal Plain	11.9	7.7	20.8
Western Coulees and Ridges	25.2	10.3	3.1
Western Prairie	38.7	17.3	2.0

Source: U.S. Census Bureau (USCB 2010).

Superior Coastal Plain, Northwest Lowlands, and Northwest Sands counties all had higher than average poverty rates. Poverty rates were lowest in the Central Lake Michigan Coastal (6.9%) and the Southeast Glacial Plains counties (7.1%).

Residential Property Values

Because the U.S. Census Bureau reports county-wide home values as medians instead of means, no average per ecological landscape county approximation could be calculated. Residential property values cited here are derived by dividing 2006 counts of number of housing units (USCB 2009) by the total residential property value in 2006 in that locality. Total residential property value includes both residential land and the improvements (structures and homes) on that residential land. The average residential property value per housing unit is meant to be used in relative terms, as a proxy for average home value, to compare the differences between regions in value of housing stock. Especially important to note about numbers cited here is that they account for not just the homes but also the land that those homes stand on. For this reason, regions with a prevalence of lake homes, large suburban lots, or other valuable property types have relatively high average value of residential property per housing unit. Regions with a larger proportion of multiple unit rentals will conversely see their average value of residential property per housing unit driven down. This figure is directly related to the relative tax base of the regions in the state and points to ecological landscapes with wealth or dearth of property tax income due to housing values.

Because of the prevalence of recreational homes and waterfront property, the Northern Highland counties had an especially high average residential property value per housing unit ($207,285) (Table 3.29). For reasons more associated with large suburban homes on large residential lots, the Western Prairie counties also had a high average residential property value per housing unit ($190,627), as did the Southeast Glacial Plains counties ($164,504). Average residential property value per housing unit were lowest in the Southwest Savanna counties ($86,167) and Central Sand Plains counties ($88,828), regions with little urban influence to drive up property values.

Important Economic Sectors

Importance of economic sectors within ecological landscape county approximations when compared to the rest of the state was evaluated using an economic base analysis to yield a standard metric, called a ***location quotient*** (LQ) (Quintero 2007). Economic base analysis compares the percentage of all jobs in an ecological landscape county approximation for a given economic sector to the percentage of all jobs in the state for the same economic sector. For example, if 10% of the jobs within an ecological landscape county approximation are in the manufacturing sector and 10% of all jobs in the state are in the manufacturing sector, then the LQ would be 1.0, indicating that this ecological landscape county approximation contributes jobs to the manufacturing sector at the same rate as the statewide average. If the LQ is greater than 1.0, the ecological landscape county approximation is contributing more jobs to the sector than the state average. If the quotient is less than 1.0, the ecological landscape county approximation is contributing fewer jobs to the sector than the state average.

In general, a higher location quotient is analogous to a relatively important industry within the given ecological landscape county approximation. Ecological landscape county approximations that have highly diversified economies, such as the Southeast Glacial Plains counties with a mix of urban and rural areas, will have moderate location quotients across most industries. Conversely, ecological landscape county approximations with highly specialized economies, such as the heavily agricultural Southwest Savanna counties, have a few industry sectors with quite high LQ values and many sectors with low LQ values.

Location quotients may be compared within ecological landscape county approximations across all sectors and within industry sectors across all ecological landscape county approximations (Table 3.30). This brief analysis will focus on identifying ecological landscape county approximations with outstanding LQ values in 2007 within each industry sector and how those data describe the economic character of those ecological landscape county approximations:

- The Agriculture, Fishing & Hunting economic sector is comprised primarily of farming operations. Fishing and hunting in this sector refers to commercial fishing and hunting operations that extract economic value from the land, similar to farming in an economic sense. This sector is a dominant sector in many of the rural areas of the state. This sector is most prevalent in the Southwest Savanna counties, with a LQ value of 4.46, higher than any other LQ for any industry sector or ecological landscape county approximation in the state. Seven other ecological landscape county approximations have percentages of their employment in farming at more than twice the rate as in the state as a whole (LQ values greater than 2.0). The Agriculture, Fishing & Hunting sector has the highest LQ of any sector for each of the following five ecological landscape county approximations: Northern Lake Michigan Coastal, Central Sand Plains, Western Coulees and Ridges, Western Prairie, and Central Sand Hills.
- The Forest Products & Processing sector tends to be most prevalent in northern ecological landscape county approximations. The North Central Forest counties have by far the highest employment LQ for Forest Products & Processing (3.43) statewide. The LQ for Forest Products & Processing is 2.4 in the Forest Transition counties, higher than the LQ for any other industry sector for those counties. Northeast Sands counties are also comparatively dependent on the Forest Products & Processing sector, with an employment LQ of 2.2, second highest among all industry sectors. Forest Products & Processing also

Table 3.28. *Per capita income, average earnings per job, unemployment rate, and poverty rate by ecological landscape county approximation.*

Ecological landscape county approximation	Per capita income[a]	Average earnings earnings	Percent unemployment rate[b]	Percent poverty rate[c]
Wisconsin	**$34,405**	**$36,142**	**4.7%**	**10.2%**
Central Lake Michigan Coastal	$36,555	$35,826	4.4%	6.9%
Central Sand Hills	$30,777	$30,121	4.9%	8.7%
Central Sand Plains	$29,022	$32,728	5.1%	10.3%
Forest Transition	$29,814	$31,660	5.1%	8.9%
North Central Forest	$26,738	$27,862	5.8%	10.7%
Northeast Sands	$27,677	$28,571	6.5%	10.1%
Northern Highland	$31,593	$27,444	6.1%	9.0%
Northern Lake Michigan Coastal	$29,661	$27,727	5.8%	8.9%
Northwest Lowlands	$26,396	$31,072	5.0%	12.1%
Northwest Sands	$26,208	$28,113	5.7%	11.7%
Southeast Glacial Plains	$38,934	$37,551	4.1%	7.1%
Southern Lake Michigan Coastal	$34,019	$40,675	5.6%	15.2%
Southwest Savanna	$28,795	$27,803	4.4%	8.9%
Superior Coastal Plain	$26,597	$29,237	5.5%	12.4%
Western Coulees and Ridges	$29,363	$30,057	4.3%	10.5%
Western Prairie	$32,907	$30,086	4.7%	5.4%

Sources:

[a]U.S. Bureau of Economic Analysis, 2006 figures.

[b]U.S. Department of Labor, Bureau of Labor Statistics, Local Area Unemployment Statistics, 2006 figures.

[c]U.S. Census Bureau, Small Area Income and Poverty Estimates, 2005 figures.

Table 3.29. *Residential property value, number of housing units, and average value per housing unit by ecological landscape county approximation, 2006.*

Ecological landscape county approximation	Residential property value[a]	Number of housing units	Average residential property value per housing unit
Wisconsin	**$340,218**	**2,538,538**	**$134,021**
Central Lake Michigan Coastal	$45,143	345,975	$130,480
Central Sand Hills	$11,028	88,593	$124,482
Central Sand Plains	$11,935	134,363	$88,828
Forest Transition	$32,058	301,416	$106,359
North Central Forest	$17,551	150,330	$116,751
Northeast Sands	$5,673	57,373	$98,872
Northern Highland	$12,301	59,343	$207,285
Northern Lake Michigan Coastal	$12,442	92,596	$134,368
Northwest Lowlands	$2,158	21,403	$100,809
Northwest Sands	$8,338	60,200	$138,506
Southeast Glacial Plains	$147,135	894,414	$164,504
Southern Lake Michigan Coastal	$64,395	557,129	$115,583
Southwest Savanna	$4,668	54,170	$86,167
Superior Coastal Plain	$4,930	43,720	$112,772
Western Coulees and Ridges	$25,166	261,425	$96,264
Western Prairie	$9,143	47,963	$190,627

Sources: Data, except housing units, from Wisconsin Property Tax Master Data Files, personal communication, D. Huegel, Wisconsin Department of Revenue. Housing units data from U.S. Census Bureau estimates for July 1, 2006.

[a]In millions of dollars.

Table 3.30. *Location quotients for employment by ecological landscape county approximation.*

Industry	(2007 jobs)	CLMC[a]	CSH	CSP	FT	NCF	NES	NH	NLMC	NWL	NWS	SEGP	SLMC	SWS	SCP	WCR	WP
Agriculture, fishing, & hunting	110,408	0.87	2.14	2.41	2.15	2.15	1.90	0.50	2.71	0.43	1.29	0.76	0.10	4.46	0.87	2.36	2.30
Forest products & processing	88,089	1.64	0.98	1.83	2.40	3.43	2.20	1.33	1.74	0.41	1.07	0.65	0.32	0.45	1.44	0.96	0.69
Mining	3,780	1.08	1.64	0.79	0.79	2.69	3.55	0.91	2.16	0.16	0.34	1.47	0.19	0.62	0.08	0.77	1.21
Utilities	11,182	2.44	1.08	0.81	0.39	0.61	0.45	0.58	0.41	1.96	1.76	0.67	0.65	0.81	1.83	1.19	0.51
Construction	200,794	1.12	1.02	0.89	0.96	1.14	0.92	2.38	1.08	1.07	1.14	1.08	0.67	0.98	1.13	1.03	1.11
Manufacturing (non-wood)	417,139	1.23	1.02	0.74	0.98	0.90	1.37	0.21	1.15	0.49	0.59	1.19	0.87	0.78	0.46	0.77	0.99
Wholesale trade	131,751	0.99	0.63	0.61	0.95	0.62	0.53	0.47	0.60	1.15	0.72	1.16	0.98	0.89	0.76	0.83	0.53
Retail trade	320,954	1.01	1.00	0.99	1.11	1.11	1.00	1.66	1.03	1.30	1.19	1.02	0.80	1.69	1.11	1.11	1.13
Tourism-related	399,054	0.99	1.12	0.97	0.86	0.99	1.05	1.51	1.28	1.34	1.41	0.94	1.02	0.78	1.33	1.08	1.12
Transportation & warehousing	108,919	0.95	1.32	2.13	1.40	1.19	1.15	0.80	0.89	3.25	2.15	0.82	0.83	0.74	2.12	1.39	0.99
Information	57,081	0.76	0.49	0.69	0.74	0.58	0.68	0.80	0.70	0.38	0.49	1.22	1.11	1.09	0.64	0.62	0.57
Finance and insurance	168,412	1.22	1.31	0.89	0.96	0.56	0.46	0.43	0.48	0.47	0.46	1.04	1.18	0.65	0.45	0.70	0.55
Real estate, rental & leasing	106,215	0.84	0.73	0.59	0.60	0.52	0.34	1.37	0.95	0.42	0.50	1.17	1.14	0.47	0.46	0.87	0.66
Professional, scientific, & technical services	166,353	0.85	0.53	0.46	0.55	0.41	0.36	0.43	0.45	0.51	0.47	1.04	1.51	0.49	0.47	0.63	0.81
Management	43,009	0.80	0.26	0.63	0.54	0.37	0.21	0.17	0.24	0.65	0.47	0.94	1.62	0.08	0.64	0.87	0.45
Administrative & support, waste, & remediation services	166,405	0.99	0.42	0.43	0.46	0.34	0.23	0.61	0.34	0.61	0.43	0.92	1.64	0.58	0.51	0.70	0.63
Private education	57,373	0.86	0.68	0.39	0.42	0.86	0.72	0.87	0.55	0.08	0.12	0.80	1.94	0.09	1.53	0.68	0.55
Health care & social services	379,538	0.85	0.88	1.27	1.04	0.82	0.90	0.87	0.84	0.96	0.91	0.83	1.32	0.84	0.99	1.09	0.94
Other services	187,939	1.08	1.32	1.10	1.05	1.10	1.13	1.25	1.19	1.36	1.09	1.06	0.84	1.14	1.13	0.91	1.29
Government	430,767	0.78	1.09	1.11	1.03	1.26	1.36	1.08	1.03	1.36	1.54	1.04	0.89	1.15	1.50	1.14	1.21

Source: Data calculated from U.S. Census Bureau County Business Patterns web page (USCB 2007).

[a]Shaded values represent the highest location quotient (LQ) for that industrial sector (**red**), highest LQ for that ecological landscape (**teal**), and highest LQ for both industry sector and ecological landscape (**green**). See Glossary, Part B for definitions of economic sectors.

ranks second among all industry sectors for employment LQ in the Central Lake Michigan counties. Forest Products & Processing is the third-ranked industry in terms of employment LQ for both the Central Sand Plains and Northern Lake Michigan Coastal counties.

- The Mining sector is a relatively minor source of employment in Wisconsin, supplying only 0.1% of all jobs statewide. Mining has its largest employment LQ in the Northeast Sands counties (3.55), but that figure represents only 156 jobs in 2007.
- Similarly, the Utilities sector is a minor employer in Wisconsin, comprising only 0.3% of all jobs statewide. The Central Lake Michigan Coastal counties have the highest employment LQ for the utilities sector (2.44), representing nearly 40% of all utility employment in the state.
- The Construction sector tends to have employment LQs hovering relatively close to 1.0 in most ecological landscape county approximations, indicating that Construction tends to be more or less evenly distributed across the state. For 14 ecological landscape county approximations, the employment LQ ranges only from 0.89 to 1.14. However, the Northern Highland counties have an unusually high LQ for the Construction sector (2.38), due primarily to the prevalence of second home and vacation property building associated with the region's tourism-based economy. Conversely, the Southern Lake Michigan counties have the lowest employment LQ (0.67) among all ecological landscape county approximations.
- The Manufacturing (non-wood) sector, while providing more jobs than all sectors other than Government in the state, has only five ecological landscape county approximations with employment LQs greater than 1.0. The Northeast Sands counties have the highest employment LQ (1.37) in the state. However, the relatively large economies of the Central Lake Michigan Coastal counties (employment LQ of 1.23) and the Southeast Glacial Plains counties (1.19) are the main sources of manufacturing employment importance in the state. The Manufacturing (non-wood) sector also employs at slightly higher rates in the Northern Lake Michigan Coastal counties (employment LQ of 1.15) and the Central Sand Hills counties (1.02).
- Nearly 46% of employment within the Wholesale Trade sector occurs in the Southeast Glacial Plains counties, where its employment LQ is 1.16. This is the smallest leading employment LQ for any industry sector, suggesting that Wholesale Trade is relatively evenly distributed across the regional economies of the state.
- The Retail Trade sector is Wisconsin's fifth-leading employer. Only the populous Southern Lake Michigan Coastal counties (0.80) have an employment LQ significantly less than 1.0, which means that retail trade employment is proportionally much lower in this urban, relatively large chunk of the state's economy. Conversely, employment LQ values are highest in more rural ecological landscape county approximations, such as the Southwest Savanna counties (1.69) and the Northern Highland counties (1.66).
- With nearly 400,000 jobs in 2007, the tourism-related sector (as grouped in this analysis) is Wisconsin's third-leading employer. The highest employment LQ for the tourism-related sector occurs in the Northern Highland counties (1.51). Other northern ecological landscape county approximations, generally considered part of Wisconsin's northern vacationland, also have higher employment LQ values in the tourism-related sector.
- The Transportation & Warehousing sector has its highest employment LQ in the Northwest Lowlands counties (3.25), which is also higher than for any other industry sector in that ecological landscape county approximation. Transportation and Warehousing also has the highest-ranked employment LQ value among all industry sectors for both the Northwest Sands counties (2.15) and the Superior Coastal Plain counties (2.12). These three ecological landscape county approximations are all located in northwest Wisconsin, where the influence of the port of Superior on Lake Michigan likely plays a part in the relatively high influence of the Transportation & Warehousing sector locally.
- The Information sector is logically concentrated in southern Wisconsin, along with the majority of the state's population and the associated urban influence. The Southeast Glacial Plains counties have the highest employment LQ for the Information sector (1.22), followed by the Southern Lake Michigan Coastal counties (1.11) and the Southwest Savanna counties (1.09). All other ecological landscape county approximations have employment LQ values below 1.0.
- The Finance & Insurance sector is relatively most prevalent in the Central Sand Hills counties (employment LQ value of 1.31), followed by the Central Lake Michigan Coastal counties (1.22), the Southern Lake Michigan Coastal counties (1.18), and the Southeast Glacial Plains counties (1.04). With the notable exception of the Central Sand Hills counties, these represent the most populous ecological landscape county approximations in the state. All other Finance & Insurance employment LQ values are below 1.0.
- The Real Estate, Rental & Leasing sector, closely tied to tourism and second-home activities, is highly represented in the Northern Highland counties, where it has an employment LQ of 1.37. In the remainder of the state, only the highly urbanized Southeast Glacial Plains counties (employment LQ value of 1.17) and the Southern Lake Michigan Coastal counties (1.14) have employment LQ ratios higher than in the state as a whole.

- The Professional, Science & Technical Services sector is most highly concentrated in the Southern Lake Michigan Coastal counties, where its employment LQ is 1.51. The lone other ecological landscape county approximation with an employment LQ value above 1.0 is the Southeast Glacial Plains counties (1.04).
- The Management sector is relatively minor (1.2% of employment statewide) and nearly nonexistent in many rural ecological landscape county approximations. Management employment is highly concentrated in the urban Southern Lake Michigan Coastal counties, where its employment LQ is 1.62.
- The Administration, Support, Waste & Remediation sector follows a similar trend to the Management sector, with its employment highly concentrated in the urban Southern Lake Michigan Coastal counties, where its employment LQ is 1.64.
- The Private Education sector is most highly represented in the Southern Lake Michigan Coastal counties, where its employment LQ of 1.94 is higher than for any other sector in those counties. The Superior Coastal Plain counties (1.53) are the only other ecological landscape county approximation with an employment LQ value greater than 1.0.
- The Health Care & Social Services sector is Wisconsin's fourth leading employer statewide and is relatively evenly distributed across the state, due to the inherent need for health care services for the entire population. However, the employment LQ for the Health Care & Social Services sector is considerably larger in the Southern Lake Michigan Coastal counties (1.32) and the Central Sand Plains counties (1.27).
- Employment LQs for the Other Services sector tend to be relatively constant across ecological landscape county approximations statewide. The Northwest Lowlands counties (1.36) have the highest employment LQ value for the Other Services sector. More notable is that only two ecological landscape county approximations have employment LQ values less than 1.0: the Western Coulees and Ridges counties (0.91) and the Southern Lake Michigan Coastal counties (0.84).
- The Government sector is the largest employer in the state and tends to employ proportionally the most in the north. The Northwest Sands counties (1.54) have the highest employment LQ for the Government sector, followed closely by the Superior Coastal Plain counties (1.50), the Northwest Lowlands counties (1.36), and Northeast Sands counties (1.36). Only the Southern Lake Michigan Coastal counties (0.89) and the Central Lake Michigan Coastal counties (0.78) employ government workers below the statewide rate.

For definitions of economic sectors, see the North American Industry Classification System web page (USCB 2012).

Appendix 3.A. *Vertebrate Species of Greatest Conservation Need (SGCN) significantly associated with an ecological landscape. (Red "X" in body of table indicates ecological landscapes most important for managing that SGCN in Wisconsin.)*

VERTEBRATE SGCN	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
MAMMALS																
American marten *Martes americana*					**X**											
Big brown bat *Eptesicus fuscus*	X	**X**	**X**	X	X	X	X	X	X	X	**X**	X	X	X	**X**	X
Eastern pipistrelle *Pipistrellus subflavus*		X	X								X		**X**		**X**	**X**
Eastern red bat *Lasiurus borealis*	X	X	X	**X**	X	X	X	X	X	X	**X**	**X**	X	X	X	X
Franklin's ground squirrel *Spermophilus franklinii*		X	X							**X**	X	X		X	**X**	
Gray wolf *Canis lupus*			**X**		**X**		X		**X**	X				X		
Hoary bat *Lasiurus cinereus*	X	X	X	X	X	X	X	X	X	X	**X**	X	X	X	**X**	X
Little brown bat *Myotis lucifugus*	X	**X**	**X**	X	**X**	X	**X**	X	X	X	**X**	X	**X**	X	**X**	X
Northern flying squirrel *Glaucomys sabrinus*					**X**	**X**	X	X	X	X				**X**		
Northern Long-eared Bat *Myotis septentrionalis*	X	**X**	X	**X**	**X**		**X**	**X**	X	X	X		X		**X**	X
Silver-haired Bat *Lasionycteris noctivagans*				**X**	**X**	X	**X**	X	X		X				X	
Water shrew *Sorex palustris*					**X**	X	**X**	X	X	X				X		
Woodland jumping mouse *Napaeozapus insignis*				**X**	**X**		**X**		X					**X**		
BIRDS																
Acadian Flycatcher *Empidonax virescens*		X									X				**X**	
American Bittern *Botaurus lentiginosus*		X	**X**	X	X				X	X	**X**			X		
American Golden Plover *Pluvialis dominica*				**X**			X	X		**X**	**X**			X		
American Woodcock *Scolopax minor*	X	**X**	**X**	X	**X**	X	X	X	X	X	X			X	X	
Bald Eagle *Haliaeetus leucocephalus*		X	X	X	X	X	**X**	X		X				X	X	
Bell's Vireo *Vireo bellii*													X		**X**	

Continued on next page

Appendix 3.A, continued.

VERTEBRATE SGCN	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Black Tern *Chlidonias niger*	X	X	X	X			X	X		X	**X**	X		X		
Black-backed Woodpecker *Picoides arcticus*					**X**		**X**		X	**X**						
Black-billed Cuckoo *Coccyzus erythropthalmus*	X	X	X	X	X	X		X	X	X	**X**			X	X	
Black-throated Blue Warbler *Dendroica caerulescens*				**X**	**X**	**X**	X	X						X		
Blue-winged Teal *Anas discors*	X	X	X	X				X		X	**X**			X	X	X
Blue-winged Warbler *Vermivora pinus*		**X**	X								**X**				**X**	X
Bobolink *Dolichonyx oryzivorus*	X	X	**X**	**X**		X		X		X	X	X	X	X	X	X
Boreal Chickadee *Poecile hudsonica*					**X**		**X**									
Brown Thrasher *Toxostoma rufum*	X	**X**	X	X		X	X	X	X	**X**	X	X	X	X	**X**	X
Canada Warbler *Wilsonia canadensis*					**X**		**X**	X	X					**X**		
Canvasback *Aythya valisineria*								X			X				**X**	
Caspian Tern *Sterna caspia*	**X**							**X**								
Cerulean Warbler *Dendroica cerulea*	X	X		**X**	**X**						**X**				**X**	
Common Tern *Sterna hirundo*	X							**X**			X			**X**		
Connecticut Warbler *Oporornis agilis*			**X**		**X**		X		X	**X**						
Dickcissel *Spiza americana*	X	X	X								X	X	**X**		X	**X**
Eastern Meadowlark *Sturnella magna*	X	X	X	X				X			X	X	X	X	**X**	X
Field Sparrow *Spizella pusilla*	X	**X**	X	X		X		X		X	X	X	X		**X**	X
Forster's Tern *Sterna forsteri*	**X**	X						**X**			**X**	X				
Golden-winged Warbler *Vermivora chrysoptera*			**X**	X	X	**X**	X		**X**	X				X		
Grasshopper Sparrow *Ammodramus savannarum*		X	X			X					X		X		**X**	X

Appendix 3.A, continued.

VERTEBRATE SGCN	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Great Egret *Ardea alba*	**X**							**X**							**X**	
Greater Prairie-Chicken *Tympanuchus cupido*			**X**	**X**												
Henslow's Sparrow *Ammodramus henslowii*		**X**	**X**								X	X	X		X	X
Hooded Warbler *Wilsonia citrina*											**X**				**X**	
Horned Grebe *Podiceps auritus*	**X**							**X**				**X**		X		
Hudsonian Godwit *Limosa haemastica*	X							X						**X**		
Kentucky Warbler *Oporornis formosus*															**X**	
King Rail *Rallus elegans*											**X**					
Lark Sparrow *Chondestes grammacus*															**X**	
Kirtland's Warbler *Dendroica kirtlandii*			**X**			X				X						
Least Flycatcher *Empidonax minimus*	X	X	X	X	**X**	X	**X**	X	**X**	X	X			X	X	X
Le Conte's Sparrow *Ammodramus leconteii*			**X**						**X**	X				**X**		
Lesser Scaup *Aythya affinis*	X		X	X	X		X	X		X	X	X		X	**X**	
Loggerhead Shrike *Lanius ludovicianus*													**X**			X
Louisiana Waterthrush *Seiurus motacilla*									X		X				**X**	
Nelson's Sharp-tailed Sparrow[a] *Ammodramus nelsoni*							**X**			**X**						
Northern Bobwhite *Colinus virginianus*		X											X		**X**	
Northern Goshawk *Accipiter gentilis*					**X**		**X**	X								
Northern Harrier *Circus cyaneus*	X	X	**X**	X	X			X	X	**X**	X			X	X	X
Olive-sided Flycatcher *Contopus cooperi*					**X**		**X**	**X**	X							
Osprey *Pandion haliaetus*	X		X	X	X	X	**X**	X		X						

[a]Nelson's Sharp-tailed Sparrow now named Nelson's Sparrow.

Continued on next page

Appendix 3.A, continued.

VERTEBRATE SGCN	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	*Northern Highland*	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Peregrine Falcon *Falco peregrinus*	X							X						X	**X**	
Piping Plover *Charadrius melodus*								X						**X**		
Prothonotary Warbler *Protonotaria citrea*	X		**X**								X				**X**	X
Red Crossbill *Loxia curvirostra*			X		X	X	**X**			**X**						
Redhead *Aythya americana*											**X**					
Red-headed Woodpecker *Melanerpes erythrocephalus*	X	**X**	X	X		X		X		X	X		X		**X**	X
Red-necked Grebe *Podiceps grisegena*											**X**					
Red-shouldered Hawk *Buteo lineatus*		X	X	X	X	**X**		X							**X**	
Rusty Blackbird *Euphagus carolinus*		**X**									**X**				X	
Sharp-tailed Grouse *Tympanuchus phasianellus*			X							**X**						
Short-billed Dowitcher *Limnodromus griseus*	X	X	X	X			X	X		**X**	**X**	X		X	X	X
Short-eared Owl *Asio flammeus*			X								**X**		**X**			
Spruce Grouse *Falcipennis canadensis*					**X**		**X**									
Trumpeter Swan *Cygnus buccinator*			X	X	X					**X**				X		X
Upland Sandpiper *Bartramia longicauda*	X		X					X		X			X	X	**X**	
Veery *Catharus fuscescens*	X	X	X	X	X	X	**X**	X	X	X				X	X	
Vesper Sparrow *Pooecetes gramineus*	X	X	**X**	X		**X**	X	X		**X**	X	X	X		X	X
Western Meadowlark *Sturnella neglecta*		X	X								X		X		**X**	X
Whip-poor-will *Caprimulgus vociferus*		**X**	**X**	X	X	X	X	X		X					**X**	
Whimbrel *Numenius phaeopus*	X							**X**				X		**X**		
Whooping Crane *Grus americana*		**X**	**X**								**X**					

Appendix 3.A, continued.

VERTEBRATE SGCN	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Willow Flycatcher *Empidonax traillii*	X	**X**	X					X			X	X	X		**X**	X
Wood Thrush *Hylocichla mustelina*	X	X	X	X	X	X		X			**X**	X		X	**X**	X
Worm-eating Warbler *Helmitheros vermivorus*															**X**	
Yellow-billed Cuckoo *Coccyzus americanus*		X	**X**								X				**X**	
Yellow-crowned Night-Heron *Nyctanassa violacea*															**X**	
Yellow Rail *Coturnicops noveboracensis*		**X**	**X**				**X**			X				X		
Yellow-throated Warbler *Dendroica dominica*															**X**	
HERPTILES																
Blanding's turtle *Emydoidea blandingii*		X	**X**							X	X	X	X		**X**	X
Boreal chorus frog *Pseudacris maculata*					X				X	**X**				**X**		
Butler's gartersnake *Thamnophis butleri*											**X**	X				
Eastern massasauga *Sistrurus catenatus catenatus*			**X**								X				**X**	
Eastern ribbonsnake *Thamnophis sauritus*	X										**X**					
Four-toed Salamander *Hemidactylium scutatum*	X		X	X	**X**		X		X		X			X	X	
Gophersnake *Pituophis catenifer*			**X**							**X**					**X**	
Gray ratsnake *Elaphe obsoleta*															**X**	
Mink frog *Rana septentrionalis*					X	X	**X**	X	X			X		X		
Mudpuppy *Necturus maculosus*	**X**		**X**			**X**		**X**				**X**		**X**		
North American racer *Coluber constrictor*													X		**X**	
Northern cricket frog *Acris crepitans*													**X**		**X**	
Pickerel frog *Rana palustris*											X		X		**X**	

Continued on next page

Appendix 3.A, continued.

	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Prairie ring-necked snake *Diadophis punctatus arnyi*													**X**		**X**	
Prairie skink *Plestiodon septentrionalis*										**X**					**X**	X
Ornate box turtle *Terrapene ornata*		**X**									X		X		**X**	
Queen snake *Regina septemvittata*											**X**					
Six-lined racerunner *Aspidoscelis sexlineata*															**X**	X
Slender glass lizard *Ophisaurus attenuatus*		X	**X**												**X**	
Smooth softshell *Apalone mutica*		X													**X**	
Timber rattlesnake *Crotalus horridus*															**X**	X
Western wormsnake *Carphophis amoenus*															**X**	
Wood turtle *Glyptemys insculpta*			X	X	X	X	X	X	X	X				X	**X**	X
FISH																
Banded killifish *Fundulus diaphanus*								X		**X**						
Black buffalo *Ictiobus niger*		X													**X**	
Black redhorse *Moxostoma duquesnei*				**X**												
Blue sucker *Cycleptus elongatus*															**X**	
Bluntnose darter *Etheostoma chlorosoma*															**X**	
Crystal darter *Ammocrypta (crystallaria) asprella*															**X**	X
Gilt darter *Percina evides*					X				**X**							
Goldeye *Hiodon alosoides*															**X**	
Gravel chub *Erimystax x-punctatus*											**X**					

Appendix 3.A, continued.

VERTEBRATE SGCN	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Greater redhorse *Moxostoma valenciennesi*							X		**X**	X	X					
Kiyi *Coregonus kiyi*														**X**		
Lake chubsucker *Erimyzon sucetta*											**X**					
Lake sturgeon *Acipenser fulvescens*	**X**	X	X		X	X		**X**	X		**X**			X	X	
Least darter *Etheostoma microperca*		X					**X**			X	X					
Longear sunfish *Lepomis megalotis*					X		**X**				X					
Ozark minnow *Notropis nubilus*				X							X		**X**		X	
Paddlefish *Polyodon spathula*		X													**X**	
Pallid shiner *Notropis amnis*															**X**	
Pugnose shiner *Notropis anogenus*							**X**			X						
Redfin shiner *Lythrurus umbratilis*				X							**X**					
Redside dace *Clinostomus elongatus*											X				**X**	
River redhorse *Moxostoma carinatum*									**X**	X	X				X	
Shoal chub (speckled chub) *Macrhybopsis hyostoma*		X						X							**X**	
Shortjaw cisco *Coregonus zenithicus*														**X**		
Slender madtom *Noturus exilis*											X		**X**			
Starhead topminnow *Fundulus dispar*											X				**X**	
Striped shiner *Luxilus chrysocephalus*												**X**				
Western sand darter *Ammocrypta clara*		X													**X**	

Appendix 3.B. *Responsibility species (animals only) found in each ecological landscape. (For each species highlighted in red, Wisconsin has a large portion of the global population.)*

RESPONSIBILITY SPECIES	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
MAMMALS																
American marten *Martes americana*					X											
Badger *Taxidea taxus*													X			
Beaver *Castor canadensis*					X											
Big brown bat *Eptesicus fuscus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black bear *Ursus americanus*					X				X							
Bobcat *Lynx rufus*					X				X							
Eastern pipistrelle *Pipistrellus subflavus*		X	X								X		X		X	X
Eastern red bat *Lasiurus borealis*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Elk *Cervus canadensis*					X											
Fisher *Martes pinnanti*					X											
Franklin's ground squirrel *Spermophilus franklinii*										X					X	
Gray wolf *Canis lupus*			X		X				X							
Hoary bat *Lasiurus cinereus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Little brown bat *Myotis lucifugus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Moose *Alces alces*					X				X							
Northern flying squirrel *Glaucomys sabrinus*					X	X								X		
Northern Long-eared Bat *Myotis septentrionalis*	X	X	X	X	X		X	X	X	X	X		X		X	X
River otter *Lutra canadensis*					X				X							
Silver-haired Bat *Lasionycteris noctivagans*				X	X	X	X	X	X		X				X	
Water shrew *Sorex palustris*					X		X									

Appendix 3.B, continued.

RESPONSIBILITY SPECIES	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Woodland jumping mouse *Napaeozapus insignis*				X	X		X							X		
BIRDS																
Acadian Flycatcher *Empidonax virescens*											X				X	
American Bittern *Botaurus lentiginosus*			X						X		X					
American Golden Plover *Pluvialis dominica*				X						X	X					
American Woodcock *Scolopax minor*		X	X		X											
Bald Eagle *Haliaeetus leucocephalus*					X		X								X	
Barn Owl *Tyto alba*															X	
Bell's Vireo *Vireo bellii*													X		X	
Black-crowned Night-Heron *Nycticorax nycticorax*											X					
Black Tern *Chlidonias niger*											X					
Black-backed Woodpecker *Picoides arcticus*					X		X		X	X						
Black-billed Cuckoo *Coccyzus erythropthalmus*											X					
Blackburnian Warbler *Dendroica fusca*									X							
Black-throated Blue Warbler *Dendroica caerulescens*				X	X	X										
Blue-winged Teal *Anas discors*											X					
Blue-winged Warbler *Vermivora pinus*		X									X				X	X
Bobolink *Dolichonyx oryzivorus*			X	X									X			X
Boreal Chickadee *Poecile hudsonica*					X		X									
Brown Thrasher *Toxostoma rufum*		X								X					X	
Bufflehead *Bucephala albeola*	X											X				

Continued on next page

Appendix 3.B, continued.

RESPONSIBILITY SPECIES	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Canada Goose *Branta canadensis*											X					
Canada Warbler *Wilsonia canadensis*					X		X							X		
Canvasback *Aythya valisineria*															X	
Cape May Warbler *Dendroica tigrina*									X							
Caspian Tern *Sterna caspia*	X							X								
Cerulean Warbler *Dendroica cerulea*				X	X						X				X	
Common Goldeneye *Bucephala clangula*	X							X				X				
Common Loon *Gavia immer*					X		X									
Common Merganser *Mergus merganser*	X							X				X				
Common Tern *Sterna hirundo*								X						X		
Connecticut Warbler *Oporornis agilis*			X		X		X		X	X						
Dickcissel *Spiza americana*													X			X
Double-crested Cormorant *Phalacrocorax auritus*											X					
Eastern Bluebird *Sialia sialis*											X		X			
Eastern Meadowlark *Sturnella magna*													X		X	X
Evening Grosbeak *Coccothraustes vespertinus*									X							
Field Sparrow *Spizella pusilla*		X											X		X	X
Forster's Tern *Sterna forsteri*	X							X			X					
Golden-winged Warbler *Vermivora chrysoptera*			X			X			X							
Grasshopper Sparrow *Ammodramus savannarum*													X		X	
Gray Jay *Perisoreus canadensis*							X		X							

Appendix 3.B, continued.

RESPONSIBILITY SPECIES	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Great Egret *Ardea alba*	X							X			X				X	
Great Gray Owl *Strix nebulosa*									X							
Great-blue Heron *Ardea herodius*											X					
Greater Prairie-Chicken *Tympanuchus cupido*			X	X												
Greater Scaup *Arytha marila*	X											X				
Henslow's Sparrow *Ammodramus henslowii*		X	X										X		X	X
Hooded Warbler *Wilsonia citrina*											X				X	
Horned Grebe *Podiceps auritus*	X							X				X				
Hudsonian Godwit *Limosa haemastica*														X		
Kentucky Warbler *Oporornis formosus*															X	
King Rail *Rallus elegans*											X					
Kirtland's Warbler *Dendroica kirtlandii*			X			X				X						
Lark Sparrow *Chondestes grammacus*															X	
Le Conte's Sparrow *Ammodramus leconteii*			X				X		X					X		
Least Flycatcher *Empidonax minimus*					X		X		X							
Lesser Scaup *Aythya affinis*															X	
Loggerhead Shrike *Lanius ludovicianus*													X			X
Long-tailed Duck *Clangula hyemalus*	X											X				
Louisiana Waterthrush *Seiurus motacilla*															X	
Merlin *Falco columbarius*														X		
Nashville Warbler *Vermivora ruficapilla*									X							

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Are either Laura Erickson or Brian Collins DNR?

Appendix 3.B, continued.

Photo by Laura Erickson

Responsibility Species	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Nelson's Sharp-tailed Sparrow[a] *Ammodramus nelsoni*							X			X						
Northern Bobwhite *Colinus virginianus*													X		X	
Northern Goshawk *Accipiter gentilis*					X		X									
Northern Harrier *Circus cyaneus*			X							X						
Northern Saw-whet Owl *Aegolius acadicus*									X							
Olive-sided Flycatcher *Contopus cooperi*					X		X	X	X							
Orchard Oriole *Icterus spurius*											X		X			
Osprey *Pandion haliaetus*					X		X									
Peregrine Falcon *Falco peregrinus*												X			X	
Piping Plover *Charadrius melodus*														X		
Prothonotary Warbler *Protonotaria citrea*			X												X	X
Red Crossbill *Loxia curvirostra*			X				X		X	X						
Red-breasted Merganser *Mergus serrator*	X							X				X				
Redhead *Aythya americana*											X					
Red-headed Woodpecker *Melanerpes erythrocephalus*		X	X								X		X		X	
Red-necked Grebe *Podiceps grisegena*											X					
Red-shouldered Hawk *Buteo lineatus*			X			X									X	
Rusty Blackbird *Euphagus carolinus*		X									X					
Sedge Wren *Cistothorus platensis*			X						X							
Sharp-tailed Grouse *Tympanuchus phasianellus*			X							X						
Short-billed Dowitcher *Limnodromus griseus*										X	X					

[a]Nelson's Sharp-tailed Sparrow now named Nelson's Sparrow.

Appendix 3.B, continued.

RESPONSIBILITY SPECIES	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Short-eared Owl *Asio flammeus*			X								X		X			
Spruce Grouse *Falcipennis canadensis*					X		X									
Swainson's Thrush *Catharus ustulatus*					X											
Trumpeter Swan *Cygnus buccinator*			X							X						X
Tundra Swan *Cygnus columbianus*											X				X	
Upland Sandpiper *Bartramia longicauda*			X										X		X	
Veery *Catharus fuscescens*							X									
Vesper Sparrow *Pooecetes gramineus*			X			X				X						
Western Meadowlark *Sturnella neglecta*													X		X	X
Whimbrel *Numenius phaeopus*								X						X		
Whip-poor-will *Caprimulgus vociferus*		X	X								X		X		X	
Whooping Crane *Grus americana*		X	X								X					
Willow Flycatcher *Empidonax traillii*		X													X	
Wood Thrush *Hylocichla mustelina*											X				X	
Worm-eating Warbler *Helmitheros vermivorus*															X	
Yellow Rail *Coturnicops noveboracensis*		X	X				X			X						
Yellow-billed Cuckoo *Coccyzus americanus*			X												X	
Yellow-crowned Night-Heron *Nyctanassa violacea*															X	
Yellow-headed Blackbird *Xanthocephalus xanthocephalus*											X					
Yellow-throated Warbler *Dendroica dominica*															X	

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Appendix 3.B, continued.

	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
HERPTILES																
Blanding's turtle *Emydoidea blandingii*			X												X	
Boreal chorus frog *Pseudacris maculata*										X				X		
Butler's gartersnake *Thamnophis butleri*											X	X				
Eastern massasauga *Sistrurus catenatus*			X												X	
Eastern ribbonsnake *Thamnophis sauritus*											X					
Four-toed Salamander *Hemidactylium scutatum*					X											
Gophersnake *Pituophis catenifer*			X							X	X				X	
Gray ratsnake *Elaphe obsolete*															X	
Mink frog *Rana septentrionalis*							X									
Mudpuppy *Necturus maculosus*	X		X			X		X				X		X		
North American Racer *Coluber constrictor*															X	
Northern cricket frog *Acris crepitans*													X		X	
Pickerel frog *Rana palustris*															X	
Prairie ringnecked snake *Diadophis punctatus arnyi*													*X*		*X*	
Prairie skink *Plestiodon septentrionalis*										X					X	
Ornate box turtle *Terrapene ornata*		X													X	
Queensnake *Regina septemvittata*											X	X				
Six-lined racerunner *Aspidoscelis sexlineatus*															X	
Slender glass lizard *Ophisaurus attenuatus*															X	
Smooth softshell *Apalone mutica*															X	

Appendix 3.B, continued.

	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Timber rattlesnake *Crotalus horridus*															X	
Western wormsnake *Carphophis amoenus*															X	
Wood turtle *Glyptemys insculpta*															X	
FISH																
Banded killifish *Fundulus diaphanus*										X						
Black buffalo *Ictiobus niger*															X	X
Black redhorse *Moxostoma duquesnei*				X												
Blue sucker *Cycleptus elongatus*															X	X
Bluntnose darter *Etheostoma chlorosoma*															X	
Brook trout *Salvelinus fontinalis*															X	
Crystal darter *Ammocrypta (Crystallaria) asprella*				X											X	X
Gilt darter *Percina evides*									X							X
Goldeye *Hiodon alosoides*															X	X
Gravel chub *Erimystax xpunctatus*											X		X			
Greater redhorse *Moxostoma valenciennesi*							X		X							
Kiyi *Coregonus kiyi*														X		
Lake chubsucker *Erimyzon sucetta*											X					
Lake sturgeon *Acipenser fulvescens*	X							X			X					
Least darter *Etheostoma microperca*							X									
Longear sunfish *Lepomis megalotis*							X									

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Appendix 3.B, continued.

RESPONSIBILITY SPECIES	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Mud darter *Etheostoma asprigene*															X	
Ozark minnow *Notropis nubilus*													X		X	
Paddlefish *Polyodon spathula*															X	X
Pallid shiner *Notropis amnis*															X	X
Pirate perch *Aphredoderus sayanus*															X	
Pugnose minnow *Opsopoeodus emiliae*															X	
Pugnose shiner *Notropis anogenus*							X									
Redfin shiner *Lythrurus umbratilis*											X					
Redside dace *Clinostomus elongatus*				X											X	
River redhorse *Moxostoma carinatum*									X						X	X
Shoal chub (speckled chub) *Macrhybopsis hyostoma*															X	X
Shortjaw cisco *Coregonus zenithicus*														X		
Silver chub *Macrhybopsis storeriana*															X	
Slender madtom *Noturus exilis*													X			
Slimy sculpin *Cottus cognatus*															X	
Starhead topminnow *Fundulus dispar*															X	
Striped shiner *Luxilus chrysocephalus*												X				
Weed shiner *Notropis texanus*															X	
Western sand darter *Ammocrypta clara*															X	
INVERTEBRATES																
Alkali bluet damselfly *Enallagma clausum*														X		

Appendix 3.B, continued.

RESPONSIBILITY SPECIES	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Black striate *Striatura ferrea*	X							X								
Bog fritillary *Boloria eunomia*									X							
Buckhorn *Tritogonia verrucosa*				X											X	X
Bullhead *Plethobasus cyphyus*															X	
Butterfly (a mussel) *Ellipsaria lineolata*				X											X	X
Cherrystone drop *Hendersonia occulta*	X							X								
Dentate supercoil *Paravitrea multidentata*	X							X								
Eastern elliptio *Elliptio complanata*																X
Eastern flat-whorl *Planogyra asteriscus*						X										
Ebony shell *Fusconaia ebena*															X	X
Elephant ear *Elliptio crassidens*				X											X	X
Elktoe *Alasmidonta marginata*	X															X
Ellipse *Venustaconcha ellipsiformis*											X					
Extra-striped snaketail *Ophiogomphus anomalus*						X			X							
Freija fritillary *Boloria freija*									X							
Frigga fritillary *Boloria frigga*									X							
Frosted elfin *Callophrys irus*			X													
Higgin's eye *Lampsilis higginsii*				X											X	X
Hine's emerald *Somatochlora hineana*	X							X			X					
Honey vertigo *Vertigo tridentata*						X										
Iowa Pleistocene vertigo *Vertigo iowaensis*	X							X								

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Appendix 3.B, continued.

Photo by Gregor Schuurman

RESPONSIBILITY SPECIES	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Jutta arctic *Oeneis jutta*									X							
Karner blue butterfly *Lycaeides melissa samuelis*		X	X							X						
Lake Huron locust *Trimerotropis huroniana*								X								
Liatris borer moth *Papaipema beeriana*												X				
Melissa blue butterfly *Lycaeides melissa melissa*																X
Midwest Pleistocene vertigo *Vertigo hubrichti*	X							X			X					
Monkeyface *Quadrula metanevra*				X											X	X
Mystery vertigo *Vertigo paradoxa*						X		X								
Northern blue butterfly *Lycaeides idas*						X										
Ottoe skipper *Hesperia ottoe*															X	
Phlox moth *Schinia indiana*			X							X						
Pocketbook *Lampsilis ovata venticosa*															X	
Powesheik skipperling *Oarisma powesheik*											X					
Prairie crayfish *Procambarus gracilis*												X				
Purple wartyback *Cyclonaias tuberculata*				X					X	X					X	X
Pygmy snaketail *Ophiogomphus howei*	X					X			X							X
Rainbow shell *Villosa iris*											X					
Red-disked alpine *Erebia discoidalis*									X							
Red-tailed prairie leafhopper *Aflexia rubranura*											X	X				
Regal fritillary *Speyeria idalia*											X		X		X	X
Round pigtoe *Pleurobema sintoxia*	X															*X*

Appendix 3.B, continued.

RESPONSIBILITY SPECIES	Central Lake Michigan Coastal	Central Sand Hills	Central Sand Plains	Forest Transition	North Central Forest	Northeast Sands	Northern Highland	Northern Lake Michigan Coastal	Northwest Lowlands	Northwest Sands	Southeast Glacial Plains	Southern Lake Michigan Coastal	Southwest Savanna	Superior Coastal Plain	Western Coulees and Ridges	Western Prairie
Salamander mussel *Simpsonaias ambigua*				X											X	X
Sand snaketail *Ophiogomphus smithi*																X
Silphium borer moth *Papaipema silphii*											X	X				
Six-whorl vertigo *Vertigo morsei*								X								
Slippershell mussel *Alasmidonta viridis*											X					
Slough sandshell *Lampsilis teres teres*															X	
Snuffbox *Epioblasma triquetra*	X			X							X					X
Spatterdock darner *Aeshna mutata*		X														
Spectacle case *Cumberlandia monodonta*				X					X						X	X
St. Croix snaketail *Ophiogomphus susbehcha*									X	X						
Swamp metalmark *Calephelis muticum*		X						X			X					
Tapered vertigo *Vertigo elatior*						X										
Warpaint emerald *Somatochlora incurvata*											X					
Wartyback *Quadrula nodulata*															X	
Washboard *Megalonaias nervosa*																X
Winged mapleleaf *Quadrula fragosa*				X											X	X
Yellow sandshell *Lampsilis teres*															X	
Zig-zag darner *Aeshna sitchensis*														X		

Appendix 3.C. *Scientific names of species mentioned in Chapter 3.*

Common Name	Scientific Name
American basswood	*Tilia americana*
American beech	*Fagus grandifolia*
American sycamore	*Platanus occidentalis*
Ashes	*Fraxinus* spp.
Balsam fir	*Abies balsamea*
Black oak	*Quercus velutina*
Bobolink[a]	*Dolichonyx oryzivorus*
Bur oak	*Quercus macrocarpa*
Canvasback	*Aythya valisineria*
Common butterwort	*Pinguicula vulgaris*
Dotted blazing star	*Liatris punctata*
Eastern hemlock	*Tsuga canadensis*
Eastern white pine	*Pinus strobus*
Elms	*Ulmus* spp.
Ermine	*Mustela erminea*
Hine's emerald dragonfly	*Somatochlora hineana*
Jack pine	*Pinus banksiana*
Maples	*Acer* spp.
Northern red oak	*Quercus rubra*
Northern Saw-whet Owl	*Aegolius acadicus*
Paper birch	*Betula payrifera*
Red pine	*Pinus resinosa*
Red-shouldered Hawk	*Butea lineatus*
Spruces	*Picea* spp.
Sugar maple	*Acer saccharum*
Tamarack	*Larix laricina*
White oak	*Quercus alba*
Yellow birch	*Betula alleghaniensis*

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

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